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Literature Review of Wetland Evaluation Methodologies

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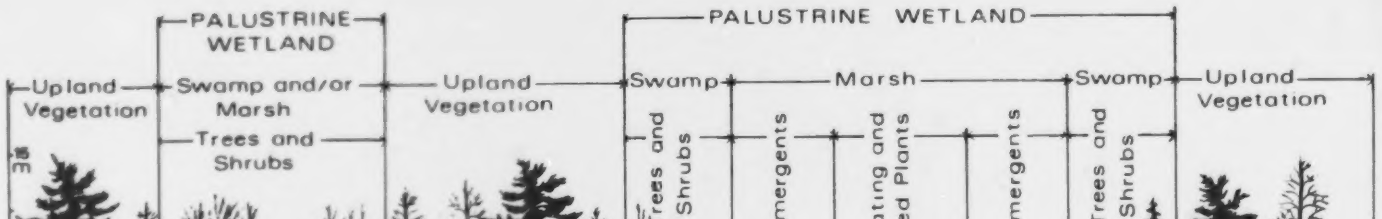
Technical Report
Literature Review Of Wetland Evaluation Methodologies

Wetland Site Types: Palustrine



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16. ABSTRACT

This report reviews and summarizes (1) direct and cumulative impacts that may result from implementation of a wastewater treatment project facilities plan; (2) the available literature concerning methodologies that have been developed to evaluate wetland ecosystem baseline conditions; and (3) methodologies that assess impacts of various human activities on wetlands. Ultimately, this information will be used by USEPA to develop an objective impact screening methodology for use during the facilities planning process. Identification of potentially adverse impacts (red flags) would allow determination of issues that would lead to the requirement of more detailed, site-specific studies. Therefore, the screening methodology would not involve extensive quantitative analysis. On the basis of the literature review it can be concluded that a large number of methodologies for assessing various aspects of wetland values and functions have been developed. No single method reviewed, however, meets the requirements of a quick screening technique to determine a broad spectrum of wetland values and functions and the potenial for adverse effects of construction grant-related activities. The vast majority of the methods reviewed deal with site-specific means to evaluate baseline ecological functions. These methods (such as HEP or HES) are highly detailed and require a significant amount of labor (although both HEP and HES can be greatly scaled down). The method developed by Adamus (1983) most closely approximates the screening method required by USEPA Region V states for facilities

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EPA Form 2220-1 (Rev. 4-77) PREVIOUS EDITION IS OBSOLETE planning, because it determines the values and functions of a wide variety of wetland characteristics, including ecology, soils, hydrology and recreation. However, in its present state the method of Adamus (1983), although defined as a rapid assessment technique, is in reality rather lengthy and requires several days to complete. It would thus be feasible for use primarily only for major projects. The State of Wisconsin is currently modifying this method so that it is not so extensive.

TECHNICAL REPORT

LITERATURE REVIEW
OF
WETLAND EVALUATION METHODOLOGIES

Prepared by:

U. S. ENVIRONMENTAL PROTECTION AGENCY
Region 5
230 South Dearborn Street
Chicago, Illinois 60604

With Assistance from:

WAPORA, Inc.
35 East Wacker Drive
Chicago, Illinois 60601

TABLE OF CONTENTS

Page

TABLE OF CONTENTS i

LIST OF TABLES iii

LIST OF FIGURES v

1.0 INTRODUCTION 1
- 1.1 Background 1
  - 1.1.1 Federal Requirements 2
  - 1.1.2 State and Local Requirements 4
- 1.2 Rationale for Present Study 5
- 1.3 Objectives 5

2.0 GENERAL DESCRIPTION OF FACILITIES PLAN-RELATED IMPACTS ON WETLANDS 9
- 2.1 Primary Impacts 10
- 2.2 Cumulative Impacts 15

3.0 LITERATURE REVIEW 17
- 3.1 U.S. Water Resources Council (WRC) Study 17
  - 3.1.1 Habitat Function 19
  - 3.1.2 Hydrologic Functions 19
  - 3.1.3 Agricultural/Silvicultural Functions 21
  - 3.1.4 Recreation and Heritage Functions 21
  - 3.1.5 Geographic Features 22
  - 3.1.6 Personnel Needs/Administrative Conditions 22
  - 3.1.7 Data Requirements 22
  - 3.1.8 Red-Flag Features 23
  - 3.1.9 Flexibility/Responsiveness 24
  - 3.1.10 End-Products/Evaluation Summary 24
  - 3.1.11 Field Testing 24
  - 3.1.12 Applicability of Methodologies to Agency Needs 25
  - 3.1.13 Conclusions and Recommendations of the WRC Study 26
- 3.2 U.S. Fish and Wildlife Service Literature Review 27
  - 3.2.1 Checklists 27
  - 3.2.2 Matrices 28
  - 3.2.3 Networks 41
  - 3.2.4 Mapping 41
  - 3.2.5 Indices 56
  - 3.2.6 Habitat Assessment Methods 60
    - 3.2.6.1 Corps of Engineers Wetland Evaluation Methodology 60
    - 3.2.6.2 Corps of Engineers Habitat Evaluation System (HES) 61
    - 3.2.6.3 U.S. Fish and Wildlife Service Habitat Evaluation Procedure 65
    - 3.2.6.4 Michigan DNR Wetland Evaluation Checklist Technique 69
  - 3.2.7 Ecosystem Modeling 71

TABLE OF CONTENTS (CONCLUDED)

Page

3.3 Other Methodologies 71
  3.3.1 Federal Highway Administration Study 71
  3.3.2 Wisconsin DNR Method 77
  3.3.3 Ludwig and Apfelbaum Matrix Method 77
  3.3.4 US Office of Technology Assessment Study (Mitigation) 81
    3.3.4.1 Examples of Wetland Impact Mitigation.. 82
    3.3.4.2 Feasibility of Wetland Impact Mitigation 88
  3.3.5 USEPA Indirect Impact Analysis Method 90
  3.3.6 USEPA Secondary Impact Analysis Methodology... 92
  3.3.7 State of New Jersey Bureau of Regional Planning Indirect Impact Analysis Methodology..... 97
  3.3.8 The Ontario Ministry of Natural Resources/ Canadian Wildlife Service Methodology......... 97

4.0 CONCLUSIONS AND RECOMMENDATIONS.......................... 102
  4.1 Conclusions.. 102
  4.2 Recommendations.. 104
    4.2.1 Incorporation of Screening Method into Facilities Planning.............................. 104
    4.2.2 Baseline Evaluation: Screening Method Requirements................................ 107
    4.2.3 Impact Analysis: Screening Method Requirements.................................... 108
    4.2.4 Recommended Screening Method.................. 111

REFERENCES 113

APPENDIX A: Summary of construction related impacts to wetlands as identified by previous studies
APPENDIX B: Summary tables from WRC study
APPENDIX C: Abstracts of wetland evaluation methodologies reviewed in Lonard et al. (1981)
APPENDIX D: Additional studies reviewed by Lonard et al. (1981) that did not meet screening criteria
APPENDIX E: Scale-weighted checklists developed by Nelson et al. (1982)
APPENDIX F: Example HQI curves used by HES (USCOE 1980)
APPENDIX G: FHWA method - selected forms (Adams 1982)
APPENDIX H: Quantitative methods for determining wetland values (from Ludwig and Apfelbaum, unpublished)
APPENDIX I: Pollution coefficients from Zimmerman (1974)
APPENDIX J: New Jersey (1975) indirect analysis methodologies
APPENDIX K: Procedure recomended by USCOE to evaluate dredge and fill sites (from Nelson et al. 1982)
APPENDIX L: Ontario Government Biological Method
APPENDIX M: Ontario Government Checklist

List of Tables

Table		Page
3.2-1.	Fish and Wildlife Service checklist of potential environmental alterations resulting from dredge and fill activities	29
3.2-2.	Part of a checklist used by the US Fish and Wildlife Service to assess impacts of dredging and filling projects	3C
3.2-3.	Part of a scaling checklist used to assess impacts of upland disposal of dredged materials	31
3.2-4.	Assessment scale-weighting checklists for type, scale, and timing factors associated with dredge and fill activities	32
3.2-5.	Descriptive matrix illustrating physical and chemical impacts of river channel dredging	34/35
3.2-6.	Critical factors used in rating and determining recovery index	58
3.2-7.	Critical factors used in determining the inertial index.	59
3.2-8.	Criteria for scaling eight factors reflecting wetland values for water purification	62
3.2-9.	Ecological problems related to dredged material disposal and features of applicable modeling methods	72
3.3-1.	Key parameters for defining wetland functional values .	79
3.3-2.	Wetland evaluation matrix devised by Ludwig and Apfelbaum	80
3.3-3.	Examples of onsite mitigation practices useful for filling and bulkheading	83
3.3-4.	Examples of mitigation practices applicable to excavation and fill for construction of highways through wetlands	84
3.3-5.	Examples of mitigation measures for control of wetland filling due to soil erosion and siltation	85
3.3-6.	Examples of mitigation measures for eutrophication from sewage effluents discharged in wetlands	86

Table		Page
3.3-7.	Examples of mitigation measures for control of temporary adverse effects from pipeline installation	87
3.3-8.	Outline of method used by the New Jersey Bureau of Regional Planning to assess indirect sewerage system impacts	98
4.1-1.	Sources of wetland data	109

List of Figures

Figures **Pages**

1.2-1. This portion of the analysis constitutes the screening method yet to be developed by USEPA 7

2.1-1. Summary of major direct impacts of WWTP construction/ operation on water resouces 12

2.1-2. Summary of the major types of impacts of wastewater on wetlands identified by USEPA 13/14

3.2-1. Interaction matrix linking project activities with associated environmental elements or effects 36

3.2-2. Impact severity matrix for scaling comparative impacts at two alternative sites for marina construction 37

3.2-3. Protion of Leopold interaction matrix with instructions for scaling and weighting impacts 38

3.2-4. Matrix for linking dredge and fill activities with physical and chemical effects 39

3.2-5. Matrix for linking physical-chemical effects of dredge and fill projects with adverse biological effects . . . 40

3.2-6. Diagram of a freshwater aquatic food web 42

3.2-7. Pictorial diagram of energy transfer in a typical riverine forested wetland 43

3.2-8. Diagram of energy transfer model for a typical riverine forested wetland 44

3.2-9. Network illustrating various habitat components for a riverine or lacustrine cover type at four levels 45

3.2-10. Network diagram of relationships among components of a channel catfish habitat suitability model 46

3.2-11. Network analysis of the sequential effects of a dredging project on coastal ecosystems 47

3.2-12. Decision tree illustrating effects of surface mining and associated dredging and filling 48

3.2-13. Map of a wetland area under consideration for construction of a marina involving channel dredging and mooring basin at two alternative sites 50

Figures **Pages**

3.2-14. US Fish and Wildlife Service National Wetlands Inventory classification scheme 51

3.2-15. Sample from a 1:24,000 scale habitat classification map showing wetlands in Colorado 52

3.2-16. Features of the "palustrine" wetland system - part of the wetland classification scheme used by the US Fish and Wildlife Service 53

3.2-17. Ecological "key" map illustrating erosion potential for a northwest coastal area watershed 54

3.2-18. Areas of Wisconsin in which wetlands have been or are currently being mapped 55

3.2-19. Detailed steps in preparing a "HES" 64

3.2-20. Generalized evaluation procedure for employing HEP . . . 66

3.2-21. Relationship between baseline conditions, conditions without a proposed action, conditions with a proposed action and net impact 68

3.2-22. Portion of MDNR wetland evaluation checklist 70

3.3-1. The relationships between the concepts of opportunity, effectiveness, and significance in evaluation of wetland values and functions 75

3.3-2. Flow chart of the method developed by Adamus (1983) to evaluate baseline conditions in wetlands and effects of highway construction 75

3.3-3. Hypothetical cost comparison using three different mitigation measures to alleviate disruption of surface and subsurface drainage due to highway construction on wetland fill 89

3.3-4. Method presented by Zimmerman (1974) to assess indirect impacts of wastewater facilities 91

3.3-5. Definitions of various sub-boundaries within the geographic area affected by 201 wastewater planning 93

3.3-6. Illustration of the concept of the "sub-area," or those portions within the economic area which are most likely to be affected by 201 planning 95

3.3-7. Example situations whereby wells located near a wetland may or may not be directly hydrologically connected . . 96

Figures **Pages**

4.2-1. Method used by Reed and Kubiak (1983) to incorporate wetland evaluation into the facilities planning process 105

1.0 INTRODUCTION

1.1 Background

Wetland communities are ecologically, recreationally, and aesthetically important systems that may be affected by implementation of wastewater management planning activities in USEPA Region V. The presence of wetlands and the specific type of wetland which may be affected by a wastewater project, however, may be difficult to determine objectively in such cases because of differences in: (1) definitions of what exactly constitutes a "wetland"*; and (2) differences in the degree of biological training of the evaluator. Problems of wetland definition involve establishing both the areal extent and type of wetland. Differences in the amount of biological training possessed by a project reviewer result in varying interpretations of wetland values. Often, persons with minimal or no biological training are required to make such determinations and a valuable area may be overlooked.

During the course of the development of a facilities plan, therefore, potentially valuable wetlands may not be objectively evaluated, depending on who is conducting the review. This can lead to adverse effects during construction and operation phases of a given project. A method is therefore needed which can be employed by Federal and State and/or their consultants agency personnel who are not necessarily trained in wetland ecology to objectively screen wetland values and potential adverse effects of individual projects on wetlands. However, at present, no consistent, standardized methodology has been developed for screening potential impacts of these activities on wetlands in USEPA Region V. This report provides a review of available methods for assessing such impacts, in order to provide the basis for: (1) selecting an existing screening methodology which may be suitable for use in Region V; (2) selecting an existing methodology which may be modified for this same purpose; or (3) allow development of a new screening method.

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* This document uses the wetland definition developed by Cowardin et al. (1979) and currently employed by USEPA. This definition is as follows: "Wetlands are lands transitional between terrestrial and aquatic systems where the water table is usually at or near the surface or the land is covered by shallow water. For purposes of this classification wetlands must have one or more of the following three attributes: (1) at least periodically, the land supports predominantly hydrophytes, (2) the substrate is predominantly undrained hydric soil, and (3) the substrate is nonsoil and is saturated with water or covered by shallow water at some time during the growing season of each year."

The concern for developing an objective standardized method of evaluating impacts of wastewater treatment projects on wetlands has arisen historically from the protection which these natural communities have been afforded by numerous Federal, state and local laws and regulations. Communities and organizations that plan to build and operate treatment systems that may affect wetlands are confronted with an array of legal considerations. These result from requirements of the Federal Clean Water Act, the Rivers and Harbor Act of 1899, two Executive Orders, and certain precedents being established within the states. These will be briefly reviewed here in order to provide a suitable background for the remainder of the present report.

1.1.1 Federal Requirements

When most Federal laws and policies for protection of wetlands were adopted, multiple uses for such areas were not considered. The regulations were adopted primarily to remove these areas from development considerations and to discourage activity which could damage natural wetlands. The following sections briefly outline the protection afforded wetlands under the major Federal laws.

The Clean Water Act. The Clean Water Act provides broad statutory authority for protecting wetlands and other waters of the United States, and establishes an institutional framework for implementing wetland protection. This framework includes the facilities planning process under Title II, the Section 303 water quality standards process, the Section 402

National Pollutant Discharge Elimination System (NPDES) permit program, and the Section 404 Dredge and Fill permit program. The facilities planning process provides for a detailed review of the impacts of wastewater treatment projects on sensitive environmental resources, while the water quality standards establish limits on levels of pollutants in the waters of the United States. However, primary protection of wetlands is implemented through the 404 permit program and the NPDES permit program.

The Section 404 permit prevents destruction or alteration of wetlands by regulating activities which result in the disposal of dredged or fill materials in wetland areas. While the 404 permit protects wetland areas, it is actually a regulation of dredge and fill activities. If there is not placement of dredge or fill material, no permit is needed. A 404 permit could be necessary if a new facility required dredging activities in natural wetlands or if outfall structures were to be constructed in a wetland that is considered to be within the waters of the United States.

Under Section 402 of the Clean Water Act, the discharge of effluents directly to the navigable waters, including wetlands, of the U.S. requires an NPDES permit and a program to monitor the discharge. Under this section of the Act, most municipal treatment facilities must provide wastewater treatment at secondary or higher levels.

The Rivers and Harbors Act of 1899. Section 10 of this Act requires that all persons who wish to build any structure or undertake any type of work in the navigable waters of the United States first obtain a permit from the Corps of Engineers. When built within the navigable waters of the United States, a Section 10 permit will be required for the construction or placement of piers, wharfs, weirs, booms, breakwaters, bulkheads, revetments, jetties, and any permanent or semi-permanent obstacle or obstruction. A Section 10 permit is also required for any modification of a navigable water of the United States. These modifications include dredging, excavating, filling, and the disposal of dredge spoil.

Executive Order 11990, Protection of Wetlands. Under Executive Order 11990, actions taken by Federal agencies must minimize the degradation of wetlands and must preserve and enhance the natural and beneficial values of wetland areas. For communities wishing to use natural wetlands as part of their wastewater treatment systems or for projects involving direct wetland elimination by filling, and where no practical alternative has been identified, this Executive Order presents the issue of what constitutes "degradation" (lowering of the natural values of the system beyond acceptable levels). Certain interpretations of the Order have also held that the mandate not only prohibits the use of a natural wetland as part of a wastewater treatment system, but that it also restricts the discharge of fully treated effluents to wetland areas, except under special situations. The interpretation of the degree of "lowering" of wetland values varies with the agency or individual conducting the evaluation, however.

Executive Order 11988, Floodplain Management. Executive Order 11988 requires Federal agencies to avoid any direct or indirect support of floodplain development. The Order also directs Federal agencies to provide leadership in acting to: (1) reduce the risk of losses due to flooding; (2) minimize the impact of floods on human safety and health; and (3) preserve the natural and beneficial value of floodplains. Many natural wetlands are located within the 100-year floodplain, as are many areas that communities might consider suitable for the development of artificial wetlands.

1.1.2 State and Local Requirements

Wetland areas are also protected under a variety of state and local regulations. State statutes frequently address water quality, floodplain development, and wetlands protection. Language in an approved Coastal Zone Management Plan may prohibit wetland degradation on the coastal areas of Region V states. Local regulations may also protect wetlands through zoning regulations, subdivision restrictions, building codes, sanitation codes, conservation districts, or special-use permit regulations. Deed restrictions may also exist for individual sites.

1.2 Rationale for Present Study

Although wetlands are protected by laws and Executive Orders as described above, several unresolved issues regarding the effects of wastewater treatment facility construction and operation on wetlands may arise during the 201 planning process. Issues of primary concern are: (1) how to objectively define existing baseline conditions within a wetland; and (2) how to accurately assess the direct and cumulative impacts of a 201 project on wetlands.

A variety of methodologies have been developed and used for assessing baseline conditions and the impacts of various activities on wetlands. However, no consistent evaluation methodology is currently being employed by all government agencies within USEPA Region V during facilities planning. As a result, a wide variety of values (or lack of values) may be ascribed to wetland communities during completion of baseline assessments. In addition, analyses of potential impacts also have varied widely with respect to scope and depth.

In short, large differences may result in the quality of the environmental analysis conducted on wastewater treatment projects involving wetlands. Nevertheless, it is desirable that a consistent methodology for screening potentially adverse effects of such activities be developed for use by planning agencies and organizations, so that objective and well-balanced facilities planning decisions can be made. This is essential especially in view of the ecological, recreational, and aesthetic values associated with natural wetlands and the various Federal, state, and local protection they are afforded. The rationale for the present study has thus emerged from the need for such a methodology.

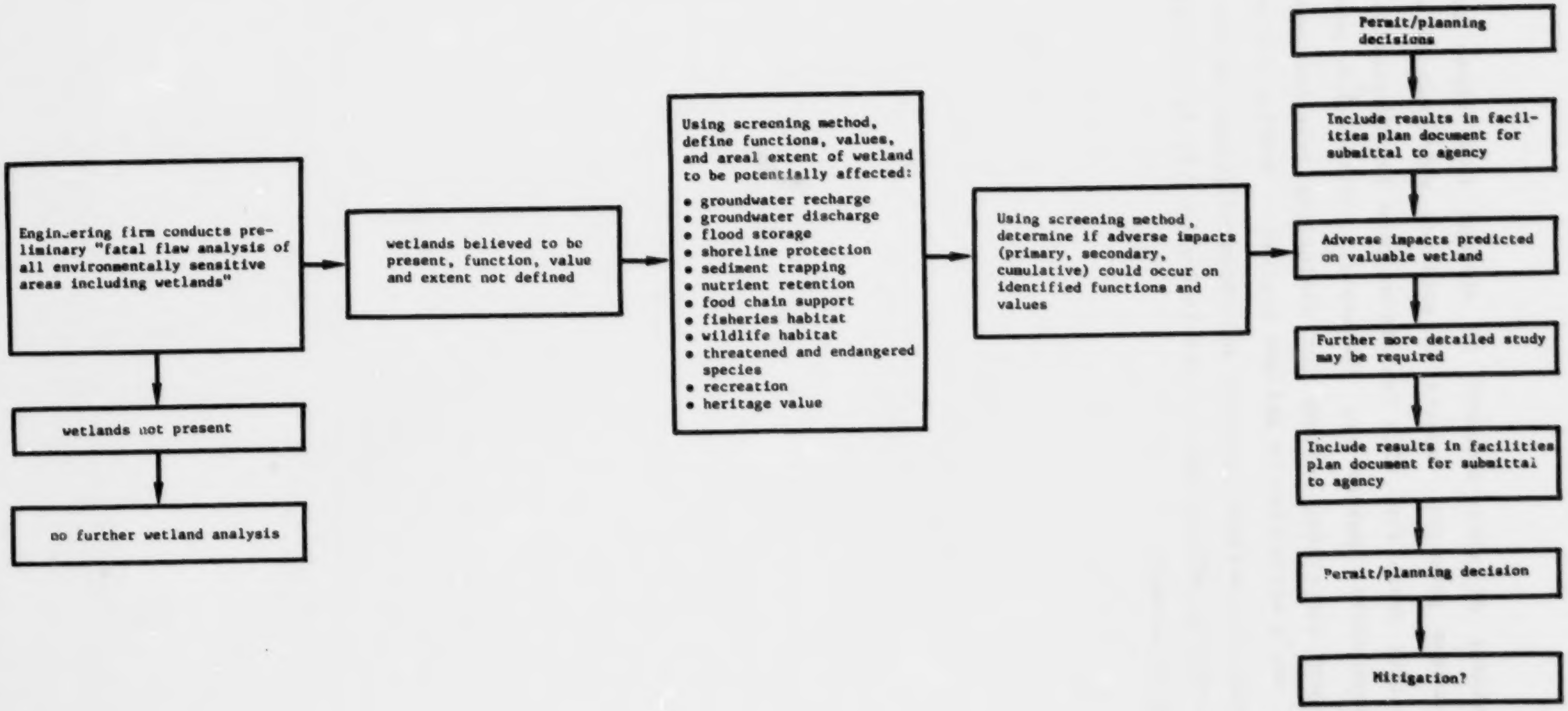
1.3 Objectives

The specific objectives of this report are to review and summarize: (1) direct and cumulative impacts that may result from implementation of a facilities plan; (2) the available literature concerning methodologies that have been developed to evaluate wetland ecosystem baseline conditions; and (3) methodologies that assess impacts of various human activities on wetlands. Ultimately, this information will be used by USEPA to develop an objective impacts screening methodology for use during the facilities planning process. Figure 1.2.1 illustrates how the screening method could be incorporated into the existing facilities plan process.

Prior to instituting the screening method, it is assumed that the engineering consultant who is preparing the facilities plan will know generally whether or not wetlands are within the study area. If wetlands are present, then the screening method would be instituted. The method would necessarily consist of two sequential sub-parts. The first step would require determination of the functions and values associated with the existing wetland(s) and the location and areal extent of these areas. Functions and values would include hydrological, geological, and biological characteristics listed in Figure 1.2-1. The next step of the screening method would require an analysis of potential secondary and primary impacts of the facilities plan implementation on wetland functions and values as defined in the first phase of the screening method.

If no adverse effects were anticipated, the results of the screening analysis would be summarized in the facilities plan. If adverse impacts were implicated, further issue specific studies might be required prior to submittal of the facilities plan in order to identify the expected nature and severity of the effects of project implementation. An alternative pathway would be to include the results of the screening analysis in the facilities plan and to use it as the basis for further planning decisions and possible mitigation (Figure 1.2-1). The screening method will ultimately enable agencies, planners, and consultants to identify critical aspects of wetlands that might warrant further study, and is not intended to be a detailed and time consuming technique. Additional detailed studies would be required only if their use were mandated because of potentially adverse effects or lack of data.

Figure 1.2.1. This portion of the analysis constitutes the screening method yet to be developed by USEPA.


Engineering firm conducts preliminary "fatal flaw analysis of all environmentally sensitive areas including wetlands"
wetlands not present
no further wetland analysis
wetlands believed to be present, function, value and extent not defined
Using screening method, define functions, values, and areal extent of wetland to be potentially affected:
• groundwater recharge
• groundwater discharge
• flood storage
• shoreline protection
• sediment trapping
• nutrient retention
• food chain support
• fisheries habitat
• wildlife habitat
• threatened and endangered species
• recreation
• heritage value
Using screening method, determine if adverse impacts (primary, secondary, cumulative) could occur on identified functions and values
Permit/planning decisions
Include results in facilities plan document for submittal to agency
Adverse impacts predicted on valuable wetland
Further more detailed study may be required
Include results in facilities plan document for submittal to agency
Permit/planning decision
Mitigation?

The remainder of this document is divided into three sections. Section 2.0 reviews potential impacts on wetlands which may result from various activities associated with facilities plan implementation. Both direct and cumulative impacts are discussed. Section 3.0 summarizes recent literature concerning methods for evaluating baseline conditions and impacts of man's activities on wetland systems. Section 4.0 presents conclusions about the methods reviewed and recommendations for the development of a screening methodology for use in Region V by facilities planners and agency personnel.

2.0 GENERAL DESCRIPTION OF FACILITIES PLANNING IMPACTS ON WETLANDS

The objective of this section is to provide a brief description of the types of impacts which can result on wetlands due to implmentation of a facilities plan. The purpose of this review is to provide a background for the literature review of wetland assessment methodologies presented in Section 3.0. Appendix A contains additional summary information concerning major impacts which may result from construction activities within wetlands due to dredge and fill activities and other types of construction. Since the types of direct impacts of these types of activities are similar to the effects of a wastewater treatment project, this summary can be used as a means of understanding some of the effects of the latter.

Several terms need to be first defined in order to clarify the discussions that follow. These include the terms primary impacts, secondary impacts, and cumulative impacts. Primary impacts are defined here as those which result directly from a construction activity. Secondary impacts is a term that has been used in the past by facility planners to signify effects of induced growth on natural and man-made resources. The typical definition is that secondary impacts are those produced by population growth induced by the availability of wastewater treatment facilities. To be consistent with the Council on Environmental Quality's (CEQ) guidelines, however, the present study includes the term secondary impacts as a subcategory of cumulative impacts. By definition, the CEQ identifies cumulative impacts as follows (CEQ regulations 29 November 1971, effective date 30 July 1979 - 40 CFR Parts 1508.7 aw 1508.8):

> "Cumulative impact is the impact on the environment which results from the incremental impact of the action when added to other past, present, and reasonably foreseeable future actions regardless of what agency (Federal or non-Federal) or person undertakes such other actions. Cumulative impacts can result from individually minor but collectively significant actions taking place over a period of time." "Effects include":
>
> (a) "Direct effects, which are caused by the action and occur at the same time and place".

(b) "Indirect effects, which are caused by the action and are later in time or farther removed in distance, but are still reasonably foreseeable. Indirect effects may include growth inducing effects and other effects related to induced changes in the pattern of land use, population density or growth rate, and related effects on air and water and other natural systems, including ecosystems."

Under this definition, a direct impact is synonymous with primary, and secondary impacts are synonymous with indirect effects, or those produced by induced changes. For consistency, the present study utilizes the CEQ definitions.

An example of a direct cumulative impact related to facilities planning would be the removal of a specified amount of wetland habitat to allow for construction of several sewage treatment plants and associated interceptor systems within a large geographical area. The direct cumulative impacts on wetlands in this case could be defined, for example, as the total number of acres of habitat directly eliminated by construction of all plants, lagoons, and interceptors (and the resulting ecological, hydrological, and water quality related impacts). Indirect cumulative impacts in this case would be defined as the number of acres of wetlands affected by induced growth produced by several facilities within the larger geographical region. Both types of cumulative effects (direct and indirect) would be expressed either as total acres eliminated (and resulting impacts) or as a percentage of the total available wetland acreage within a defined area (such as the service area or larger geographical region). A method for assessing cumulative impacts of USCOE Section 10 and 404 activities has been prepared (Coates 1981) but is not reviewed here. Adamus (1983) also briefly discussed various means to assess cumulative impacts of highway construction activities on wetlands.

2.1 Primary Impacts

Direct impacts of facilities plan implementation on wetlands may result from construction of sewage treatment plants, lagoons, interceptors, and pump stations. For detailed discussions of general construction impacts, the reader is referred to the citations in the bibliography by Darnell et al. (1976) and Nelson et al. (1982b). Wetlands may also be affected by wastewater discharges (USEPA 1983).

The major types of direct impacts that wastewater treatment plant (WWTP) construction and operation may have on water quality are illustrated in Figure 2.1-1. Vegetation removal, encroachment, alteration of hydrologic regime, and reduced water quality would all have adverse effects on wetland values.

Direct elimination of wetland habitat or encroachment of a treatment facility at the edge of a wetland could disturb or eliminate wildlife habitat, and produce increased erosion and sedimentation. Interceptor construction may result in direct habitat elimination where pipelines cross wetlands. Construction of an interceptor crossing a wetland may also cause temporary increases in runoff and erosion, producing increased sedimentation within a wetland. Increased sedimentation (from human activity) may have direct biological effects, either on wetland plants or on aquatic organisms, by direct smothering or by producing increased turbidity (similar effects also may result from WWTP interceptor construction). Construction of a wastewater treatment plant or interceptor across or adjacent to a wetland may also block water sheet flow or interfere in various ways with the overall water balance (budget) of these communities. These interferences could include groundwater, surface water, precipitation, and evapotranspiration inputs and outputs. Because almost every ecological function of wetlands is linked directly with the hydrologic regime (i.e., the balance between all water inputs and outputs), activities such as interceptor construction have the potential for producing a variety of adverse physical, chemical, and biological impacts on wetlands.

Discharges of treated wastewater into wetland ecosystems may have a variety of impacts. These were recently reviewed in detail in a Region V publication entitled The Effects of Wastewater Treatment Facilities on Wetlands in the Midwest (USEPA 1983). The major impacts on wetlands identified therein are listed in Table 2.1-2 and are not discussed further in the present review.

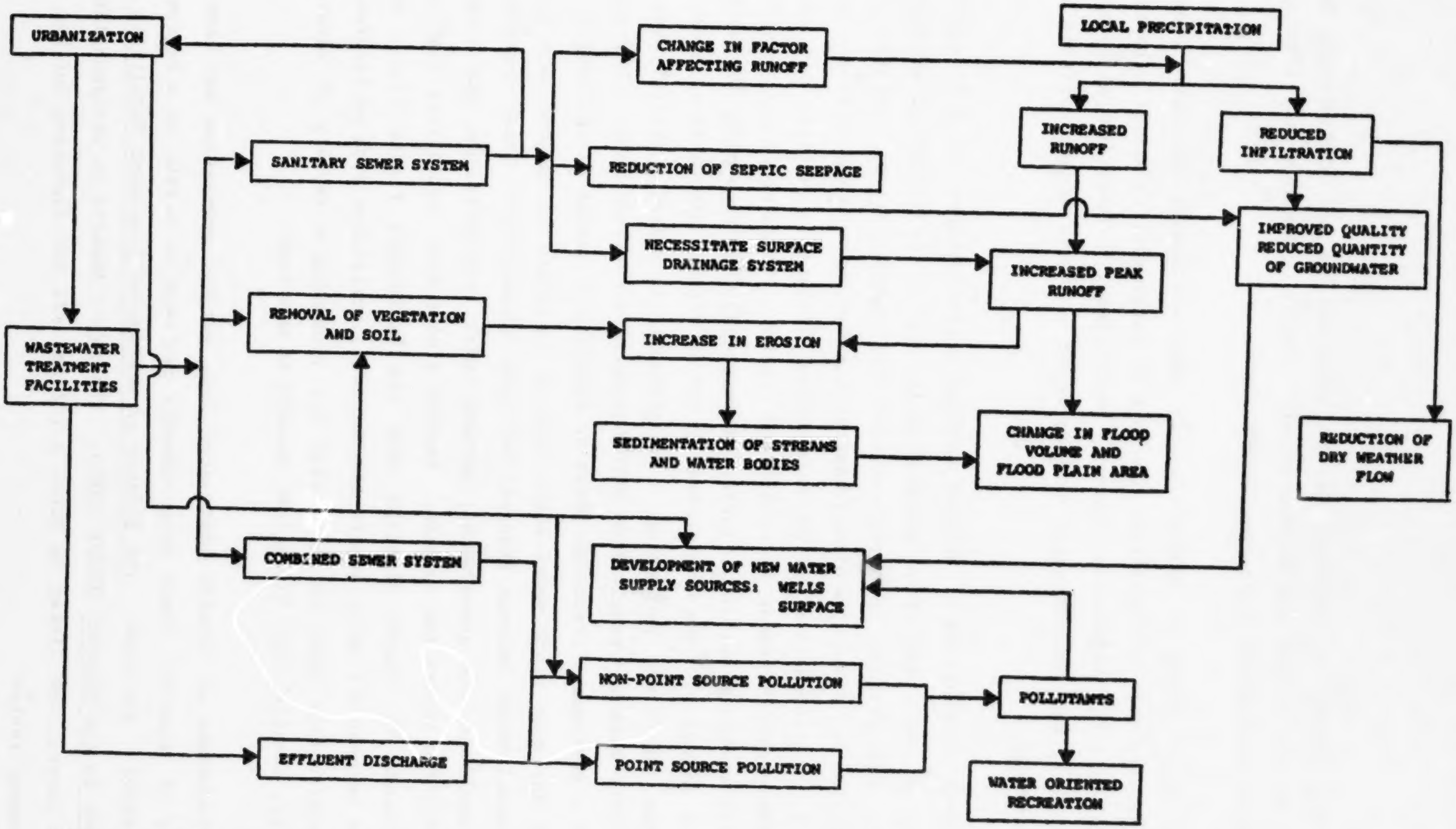

URBANIZATION
WASTEWATER TREATMENT FACILITIES
SANITARY SEWER SYSTEM
REMOVAL OF VEGETATION AND SOIL
COMBINED SEWER SYSTEM
EFFLUENT DISCHARGE
CHANGE IN FACTOR AFFECTING RUNOFF
REDUCTION OF SEPTIC SEEPAGE
NECESSITATE SURFACE DRAINAGE SYSTEM
INCREASE IN EROSION
SEDIMENTATION OF STREAMS AND WATER BODIES
DEVELOPMENT OF NEW WATER SUPPLY SOURCES: WELLS SURFACE
NON-POINT SOURCE POLLUTION
POINT SOURCE POLLUTION
LOCAL PRECIPITATION
INCREASED RUNOFF
REDUCED INFILTRATION
IMPROVED QUALITY REDUCED QUANTITY OF GROUNDWATER
INCREASED PEAK RUNOFF
CHANGE IN FLOOD VOLUME AND FLOOD PLAIN AREA
REDUCTION OF DRY WEATHER FLOW
POLLUTANTS
WATER ORIENTED RECREATION

Figure 2.1-1. Summary of major direct impacts of WWTP construction/operation on water resources (from USEPA 1978).

Table 2.1-2. Summary of the major types of impacts of wastewater on wetlands identified by USEPA (1983).

Type of Impact	Description
• Change in Hydrologic Regime	• Sequential changes in all wetland features, possibly including nutrient cycling, sedimentation rates, erosion patterns, plant and animal community composition, overall water budget; effects ultimately depend on loading rate, discharge quality, size and type of receiving wetland.
• Nutrient Cycling	• Most wetlands studied to date achieve good removal of nitrogen via denitrification; phosphorus removal is more variable and a less well known process; wastewater application alter rates of nutrient cycling in largely unknown ways.
• Accumulation of other dissolved substances (inorganic ions, sulfur compounds, BOD loading by non-toxic organisms, etc...)	• Wetlands have some ability to assimilate organic loading + other compounds but changes in soil chemistry (i.e., pH changes etc.,) may result, producing shifts in dominant plant types.
• Trace metal Accumulation	• Some metals do accumulate within wetlands, others are less well retained; bioaccumulation affected by various physical/chemical factors.
• Accumulation of refractory chemicals (i.e, surfactants, phenols, pesticides)	• Wetlands typically accumulate such compounds; long-term ecological effects poorly known.
• Soils and Sediments	• Potential erosion, channel creation; chemical leaching; litter buildup.
• Plant communities	• Shifts in species composition, areal distribution; changes in biomass, production; changes in detrital cycling; transfer of potentially toxic materials in food chain.
• Animal Communities	• Changes in wildlife, animal, and fish populations may result directly from changes in plant community, alteration of water levels or reduced water quality; increases in insect disease carrying vectors possible but not well known; benthic invertebrate communities may shift to more pollution tolerant forms.

Table 2.1-2. Summary of the major types of impacts of wastewater on wetlands identified by USEPA (1983) (concluded).

Type of Impact	Description
• Protected Species	• Possible adverse effects due to reduced water quality, changes in plant community structure, habitat elimination.
• Health/disease	• Viruses, bacterial and parasite related diseases all potential, but very poorly studied area.
• Overloading/stress	• Potential for increased stress on receiving wetlands due to added pollutants; resulting in reduced production, shifts in metabolic (energy flow) pathways; effects largely dependent on relation between amount of loading and size of wetland.

2.2 Cumulative Impacts

Cumulative impacts of construction grants project implementation may include the additive direct effects of individual WWTPs and their associated infrastructure or the indirect effects of induced growth. Construction and operation of WWTPs and associated interceptors can result in a variety of secondary induced growth impacts. These include effects on water quality and quantity due to construction and operation, or direct wetland habitat elimination caused by land use changes. Indirect impacts produced by changes in water quality and/or quantity may include the following (inferred from Zimmerman 1974):

- Positive impact can occur by improving water quality by eliminating or reducing direct discharges to wetlands and hydrologically connected areas, thereby improving ecological and recreational values;
- Potentially adverse impacts from induced development resulting in increased overland runoff, erosion, and sedimentation. Development increases the amount of impervious surface, reduces recharge areas for groundwater, increases runoff of pollutant-laden stormwater and erosion from bare construction sites, possibly resulting in adverse effects on wetlands;
- Potentially adverse effects may occur because of increased use of surface and groundwater. Decrease in recharge area may affect wetlands. The overall balance between surface and groundwater may alter wetland water budgets.

Potential indirect effects on wetlands due to land use changes caused by induced growth could include the following (based on information given in Zimmerman 1974):

- Direct wetland habitat elimination due to construction of new residential, commercial, or industrial facilities and infrastructure because of growth induced by the availability of new sewage treatment facilities; and
- Construction of new residential, commercial, or industrial facilities and associated infrastructure adjacent to wetlands as a result of induced growth producing:
  - encroachment effects on wildlife (spraying, noise, human presence),
  - blocking of surface sheet flow or other hydrologic effects (drainage, etc...),
  - increased pollutant loadings, and
  - other impacts as described in Section 2.1.

The actual indirect cumulative impacts on wetlands within a service area will depend on the rate and direction of induced growth. Since the total acreage of land affected by induced growth is much greater than that required to construct the WWTP and associated infrastructure, indirect cumulative impacts from facilities plan implementation will typically be of far greater magnitude and extent than the primary (direct) impacts. In effect, indirect impacts are an extension and amplification of the primary impacts, but extending over a larger geographical area. Indirect impacts on wetlands will be focused, however, within the areas of greatest project growth and development. Effects of induced growth are therefore typically of far greater significance than primary impacts. At present, no methodologies are available specifically for analysis of indirect effects of facilities plan implementation on wetlands. Available methods for assessing these generalized effects of types of impacts are summarized in Sections 3.3.5 through 3.3.7.

3.0 LITERATURE REVIEW

This section summarizes the recent literature concerning freshwater wetland evaluation methodologies. Methods for evaluating baseline conditions (physical, chemical and biological) as well as project-related impacts are included.

Sections 3.1 and 3.2 summarize two major literature reviews on wetland impact assessment methodologies that have been prepared recently. Section 3.3 summarizes information on other methodologies available for evaluating impacts on wetlands not included (for the most part) in the two major reviews summarized in Sections 3.1 and 3.2.

3.1 U.S. Water Resources Council (WRC) Study

The publication by the U.S. Water Resources Council (WRC) (Lonard et al. 1981) is significant because it constitutes the primary source of documentation of pre-1981 literature. The report is a detailed review of previously published wetland evaluation procedures. It was prepared for the WRC by the U.S. Army Corps of Engineers Waterways Experiment Station (WES) at Vicksburg, Mississippi (the reader should note that to avoid duplication, only a few of the final 20 papers selected for detailed analysis in the WRC study are discussed in detail again in the present report). The procedure used by the WES team was to first screen a large number of potential wetland evaluation methodologies in order to determine if they fell into one or more of the following functional categories:

Major Functional Categories	Related Functional Subcategories
Habitat	Common wetland plant and animal species Endangered, threatened, or rare plant and animal species Game species: - aquatic, terrestrial, avian Commercial species Nongame species

Hydrologic	Floodwater conveyance and storage Wave energy dissipation and shoreline protection Ground and surface water supply, including recharge and discharge Water quality, including waste assimilation and sediment trapping
Recreation	Water-oriented activities such as canoeing. Other activities such as photography, bird watching, and camping
Agriculture/Silviculture	Cultivated crops Pastureland, hay crops, forestry Peat
Heritage	Landscape: - natural and unique areas - open space Cultural: - archaeological sites - historical sites Scientific: - research - education

The study also examined the advantages and disadvantages of each selected methodology, identified where methodologies were not available or were of limited value for defining wetland functions, and prepared recommendations for improving the consistency of available wetland evaluation methodologies. Twenty documents were selected which met the screening criteria listed above. These were then analyzed in further detail to determine:

- What wetland functions were analyzed;
- Geographic applicability;
- Personnel requirements;
- Data requirements;
- "Red Flag Features";
- Method flexibility;
- End products;
- Type of field work required; and
- Possible administrative uses.

A profile of each methodology was developed from this analysis and a series of tables was developed summarizing the information. These tables are provided in Appendix B. Abstracts of the 20 final methods selected are presented in Appendix C.

3.1.1 Habitat Function

Of all methodologies reviewed, those involving ecological habitat evaluations were determined to be the most thoroughly developed. Twelve of the 20 methods reviewed dealt with habitat evaluation. Appendix Table B-1 lists the types of habitat functions included by each of the 12 methodologies. Habitat functions included abundance, distribution, and diversity of plant and animal populations; presence of rare and/or protected species; and types and abundance of game and commercial species of animals. At least five of the 20 methodologies presented require use of an interdisciplinary evaluation team.

Although well developed methods for evaluation of habitat function are available, the WRC study concluded that there is much room for improvement since each method is often based on various assumptions which need to be made because of major gaps in scientific knowledge. For example, some methods assume that selected groups of diverse plant or animal species are reflective of overall habitat value. Other types of assumptions include the following: (1) that plant community structure defines wildlife habitat requirements; (2) that there is a positive relationship between habitat diversity and wildlife species diversity; and (3) that there is a correlation between interdispersion of vegetative and wildlife diversity (New England Research, Inc. 1980).

3.1.2 Hydrologic Functions

The WRC team concluded that although the hydrologic regime is of central importance in the functioning of all wetlands, wetland hydrology is in general poorly understood and difficult to study because of its complexity. Analysis of the hydrologic regime for a wetland requires measurements of water quality, groundwater recharge, storm and floodwater storage, surface and groundwater discharge, and evapotranspiration. These measurements require substantial expenditure of labor and funds as well as use of sophisticated equipment. Considerable error may also be involved in attempting to establish a hydrologic budget (Winter 1980, 1981).

Because of this basic lack of knowledge concerning wetland hydrology, few hydrology evaluation methodologies have been developed (Lonard et al. 1981). The data base on wetland hydrology is small. Existing data are also usually contradictory or incomparable, are qualitative, and/or have been submitted to subjective interpretations (Stearns, Conrad, and Schmidt, Consulting Engineers 1979). More research is required before the hydrologic functions of wetlands can be well understood. Carter et al. (1979) identified five areas in which research on wetland hydrology is required. These include:

- Improvement of existing measurement techniques;
- Determining hydrologic inputs and outputs;
- Improvement of understanding of soil-water-vegetation relationships in wetlands;
- Long-term studies of wetland hydrology; and
- Development of models.

They concluded that evaluation criteria must be developed before adequate management decisions regarding wetland hydrology can be made. However, development of these criteria will ultimately require additional research. The ultimate goal should be to develop an evaluation system that will enable assessment of wetland hydrological values. O'Brien and Motts (1980) listed 29 factors that are hydrogeologically significant in wetlands, and suggested combinations of these that could be used to classify wetlands in various ways.

Appendix Table B-1 lists specific hydrologic parameters that can be measured according to several methodologies reviewed by Lonard et al. (1981). Three of the methods require an interdisiplinary team. Lonard et al. (1981) recommend that the methods of Reppert et al. (1979) and Schuldiner et al. (1979) be employed as a general means of evaluating impacts on wetland hydrologic functions. The method described by Reppert et al. (1978) assigns qualitative values (high, moderate or low) to individual hydrologic variables, including parameters for: (1) water quality improvement; (2) groundwater recharge; (3) storm and floodwater storage; and (4) shoreline protection values. The method developed by Schuldiner et al. (1979) includes baseline data needs, sampling techniques, data sources, and requires expertise for each hydrologic parameter to be measured. Impacts are displayed in flow charts and matrices.

3.1.3 Agricultural/Silvicultural Functions

These wetland functions include provision of forestry or food products. Lonard et al. (1981) concluded that many of the issues surrounding these wetland functions are related to defining harvest value. No methodology was identified that documented the harvest value of a wetland, but a good data base exists for determining standing crops of trees and agricultural plants (Niering and Palmisano 1979). Only one methodology was identified that should be used to evaluate silvicultural functions of wetlands (USDA 1978) (Appendix Table B-1). However, the method applies to the coast of Massachusetts and would have to be modified for applicability in USEPA Region V. No methods for specifically assessing agricultural functions were identified.

3.1.4 Recreation and Heritage Functions

Lonard et al. (1981) concluded that few methodologies were identified that address recreation and heritage values of wetlands. Such functions include a wide range of values such as boating, fishing, photography, and camping, and also historical, cultural, and aesthetic values.

Four methodologies (Appendix Table B-1) were identified that evaluate the recreation function. Two other similar methods also were identified, but these require use of an interdisciplinary team. Five other methods were identified that require an interdisciplinary team to identify heritage values (Appendix Table B-1). Niering and Palmisano (1979) suggest a procedure for development of recreation and heritage evaluation methodologies.

Lonard et al. (1981) recommended that the method developed by the USDA (1978) for coastal Massachusetts be used in the future to evaluate recreation functions. Again, however, this method must be modified in order to be applied in other areas of the country. The method of Smardon (1972), later included in a methodology developed by Larson (1976), was recommended for evaluation of heritage functions. Smardon's method could also be used as the basis for developing means of evaluating other "sociocultural" aspects of wetlands (Lonard et al. 1981).

3.1.5 Geographic Features

Lonard et al. (1981) identified methodologies developed for several geographic regions, including the glaciated northeast, southeast coastal area, freshwater wetlands in the lower Mississippi River drainage system, and for Arkansas. Eight methods (Appendix Table B-2) were identified which could be used (or modified for application) to inland and coastal wetlands. Some of these methods, however, would require major revisions to adapt them to a different geographic area.

3.1.6 Personnel Needs/Administrative Conditions

All of the methods identified by Lonard et al. (1981) require the expertise of an individual who has "the technical skills to perform a wetland evaluation" or the expertise of an interdisciplinary team of specialists (Appendix Table B-3). The team approach usually requires a major commitment of labor. The method of Galloway et al. (1978) (Appendix Table B-3) uses a team of laymen representing local interests in addition to a resource manager and the technical interdisciplinary team.

3.1.7 Data Requirements

Lonard et al. (1981) reported that the amount of data required to conduct each of the wetland evaluation methods reviewed varied greatly (Appendix Table B-4). Projects involving use of an interdisciplinary team require the largest amounts of data. Small-scale projects (typically involving regulatory actions) require far less data. Almost all methods require at a minimum, maps, aerial photographs, and some type of field survey.

The "habitat" type methods (for example, the USFWS Habitat Evaluation Procedure and the USCOE Habitat Evaluation System) require data on vegetation type and distribution. Both vegetation and hydrologic methods typically must be monitored on a seasonal basis.

All methods reviewed by Lonard et al. (1981) require value judgments by an indivudual or a team of specialists. Value judgments are based on the results of field experience and judgment of the evaluator. Some qualitative data are typically required in order to make such judgments in most of the methods reviewed. Appendix Table B-4 summarizes additional information concerning data requirements.

3.1.8 Red-Flag Features

Red-flag features include those wetland characteristics that represent an outstanding natural or cultural value. Examples include presence of protected plant or animal species, unique geological features or other biological resources (for example, highly diverse or rare habitats), or presence of archaeological resources of high value.

Seven methods were identified by Lonard et al. (1981) as including a red-flag feature that identify "key, sensitive wetland functions." The red-flag features are listed in Appendix Table B-5. Galloway (1978) identified nine "initial indicators" of wetland value. Methods developed by Carson (1976), Gupta and Foster (1973), and Smardon (1972) use the red-flag concept extensively. Schuldiner et al. (1979) employed Carson's (1976) list of red-flag features in developing a manual for assessing highway impacts on wetlands. According to Carson's method, if a wetland contains even a single red-flag feature it should be preserved. Lonard et al. (1981) note, however, that nearly all wetlands would possess at least one such feature, and that assignment of red-flag values is extremely subjective.

3.1.9 Flexibility/Responsiveness

Lonard et al. (1981) identified three methods that were flexible and responsive but that also generated relatively quick answers and were based on limited amounts of data (Appendix Table B-6). These include Carson (1976), Reppert et al. (1979), and USFWS (1980). Longer-term methods and interdisciplinary team methods require much more data and much longer periods of time to provide an evaluation. Six of the methods involved differentiating between "major" and "minor" impacts (Appendix Table B-6).

3.1.10 End-Products/Evaluation Summary

Fourteen of the 20 methodologies reviewed by Lonard et al. (1981) present a means for converting site-specific data into a numerical index for rating the value of wetlands (Appendix Table B-6). The typical end-product is a narrative describing the overall value of the wetland as "low," "moderate," or "high." The method of Galloway (1978) uses a computer and presents the summary in a graphics display. HEP (USFWS 1980) can be done manually or by computer, but the manual method is far more laborious. Two other methods (Schuldiner et al. 1979; Solomon et al. 1977) include a flow chart and matrix (or a coefficient matrix) (Appendix Table B-6).

The WRC study noted that use of a numerical rating system may result in regulatory difficulties where low values are assigned (because such a rating implies that a wetland would have little value). However, such a rating system has the advantage of presenting results of complex analysis in a summary form that is more usable for resource managers.

3.1.11 Field Testing

Lonard et al. (1981) concluded that there is a need for field testing of the various methodologies for evaluating wetlands (Appendix Table B-5) and that decision-makers should be actively involved in this process. This will ultimately lead to improvements in the quality of resource management decisions. The study recommended that further field testing of quantitative methods such as HEP and HES as well as purely qualitative methods be tested and compared in the future.

3.1.12 Applicability of Methodologies to Agency Needs

The applicability of the methods reviewed by Lonard et al. (1981) to the needs of various government agencies is summarized in Appendix Tables B-7 and B-8. Agency requirements include: (1) project planning and site selections; (2) regulatory actions; (3) impact assessments; (4) resource management; and (5) acquisition needs (the needs listed in Appendix Tables B-7 and B-8 were assigned by Lonard et al. (1981), and not necessarily by the original creators of each methodology).

Several methods were determined to be applicable to project planning and site selection procedures (Appendix Table B-7). Most of these require an interdisciplinary team and (usually) relatively large amounts of field data. Methodologies useful in regulatory actions generally require less data since they are used to produce answers in short time periods. These methods require "moderate levels of technical skills, data requirements and degrees of accuracy," but do require an experienced resource manager. Eleven methodologies were identified that address regulatory actions. Six methods reviewed involve on-site impact assessments, and all of these methods require use of an interdisciplinary team. Seven methods were identified that would meet management needs, and these have only moderate time and data requirements (Appendix Table B-7).

Twelve of the methods reviewed by Lonard et al. (1981) require low levels of man-power and data and could be used to determine mitigation procedures. Methods such as HEP (USFWS 1980), HES (USCOE 1980), and Schuldiner et al. (1979) include mitigation but the full level analysis requires more extensive amounts of data (Appendix Table B-7).

Lonard et al. (1981) also identified eleven methods that define means by which wetlands can be acquired for preservation. None require large amounts of data or manpower. Fried (1974) presented a method for acquiring wetlands in the state of New York, as well as discussion of the monetary value of wetlands.

3.1.13 Conclusions and Recommendations of the WRC Study

Lonard et al. (1981) concluded their report by making a set of recommendations concerning means of improving the existing methodologies for evaluating wetlands. The primary conclusions are as follows (quoted directly from Lonard et al. 1981):

- Progress is being made in the improvement of wetlands habitat evaluation instruments and no specific actions are recommended at this time;
- A two-phased approach should be taken to improve the assessment of hydrology values of wetlands that include the identification of scientific data gaps and the development of a specific research program that addresses technical gaps as they are related to management needs;
- No specific immediate recommendations are made concerning agriculture, recreation, and heritage functions of wetlands. However, the study team recommended actions that should be considered in the future;
- Criteria and parameters that emphasize specific wetland types and regions should be developed for inclusion in methodologies that were originally developed for widespread use;
- Personnel skill levels should be stated for new or existing methodologies;
- Data requirements are spelled out fairly well for most wetlands evaluation procedures; therefore, no recommendations are made to improve this feature of evaluation instruments;
- Red flag features should be used to indicate wetlands that require further detailed analysis;
- A well-organized field testing program should not be conducted at the present time until inconsistencies of individual methodologies are identified and improved. Field testing experiments should continue on individual methodologies in a variety of geographical areas and wetland types; and
- Various state and Federal agencies involved in wetlands management activities should assess and communicate their needs for specific evaluation instruments to authors of methodologies.

The study reviewed several additional reports on wetlands that did not meet the screening criteria and evaluation standards applied. These are listed in Appendix D. These documents were either not methodologies for evaluating wetland functions, or they evaluated wetlands on a purely monetary basis.

3.2 U.S. Fish and Wildlife Service Literature Review

The U.S. Fish and Wildlife Service (Nelson _et_ _al_. 1982c) recently published a manual designed to assist state governments in developing and implementing fish and wildlife requirements of the Section 404 program (Nelson _et_ _al_. 1982c). The manual includes a major section that reviews available methods for evaluating impacts of 404 activities on aquatic resources (including wetlands). Since these methods could also be used to address primary impacts of 201 activities, they are presented here in summary form. This section summarizes the information presented in Nelson _et_ _al_. (1982c) concerning available impact evaluation methods. Although not all methods discussed may apply specifically to wetlands, most do, or could be modified to be used in wetland assessments. In addition, the review provides a useful presentation of the range of types of methods available.

The types of methods reviewed include: (1) checklists; (2) matrices; (3) networks; (4) mapping; (5) indices; (6) habitat assessment systems; and (7) ecosystem modeling (note: where these methods have already been reviewed in this report they are cross-referenced to previous sections).

3.2.1 Checklists

Checklists are the simplest means of identifying potential environmental impacts. The advantages of checklists are: (1) they aid the evaluator's memory, ensuring that the analysis is complete; and (2) the method helps in identifying important issues. The main disadvantages are that major impacts may be overlooked if they are not included on the checklist, and that the checklist is strictly a qualitative means of assessing impacts (and is thus of limited value in quantifying degree of impact). The study identified four types of checklists that can be used in environmental impact assessments. These include: (1) simple; (2) descriptive; (3) scaling; and (4) scale-weighting checklists (Canter et al. 1977). The simple checklist provides a list of impacts that could occur but a means of further interpretation if not included (Table 3.2-1). In addition to a list of potential project impacts, the descriptive checklist may also provide a means of subjectively estimating the degree of probability of any potential adverse impacts (Table 3.2-2). In the scaling checklist, the expected degree of impact is estimated for each expected parameter (Table 3.2-3). When a weighting factor is assigned to each parameter, the scale checklist becomes scale-weighted (Table 3.2-4). Weights may be assigned mathematically or subjectively. Appendix E includes the set of scale-weighted checklists developed in Nelson et al. (1982c) to address four additional impact categories (physical factors; chemical factors; biological factors; land and water use; and other factors) associated with 404 activities. Many of these relate directly to the effects of sewer pipeline construction and other activities commonly associated with 201 plan implementation.

3.2.2 Matrices

In the matrix method, a set of cause-and-effect relationships are depicted by cross-referencing baseline conditions against a list of potential impacts. Matrices differ from checklists in that they relate specific project actions to individual impacts (i.e., the matrix is more specific). The primary advantage of the matrix is that it provides a systematic means of evaluating project impacts. Most matrices also use numbers to assess the degree or magnitude of potential impacts. The advantages of the matrix are that: (1) they are useful as a means of preliminary analysis (i.e., a screening tool); and (2) they provide for a more thorough consideration of all potential impacts, including the interactions of various project components in producing specific environmental effects (Greenberg et al. 1978). The main disadvantages are that: (1) analytical "overkill" (over-analysis of minor or irrelevant issues) may result; (2) it is hard to compare alternatives with a matrix system (a shortcoming especially rele-

_____ 1. Filled waterway or marshes

_____ 2. Deepening

_____ 3. Obstructing

_____ 4. Shoaling

_____ 5. Segmentation

_____ 6. Habitat isolation

_____ 7. Draining wetland

_____ 8. Flooding wetland

_____ 9. Bulkhead, dike, levees

_____10. Diversion of freshwater sources

_____11. Modification of tidal intrusion

_____12. Modification of water circulation

_____13. Increased fertility

_____14. Reduced fertility

_____15. Increased turbidity

_____16. Noxious odor

_____17. Tributary flow control

_____18. Saltwater barrier

_____19. Convert to fresh water

_____20. Modification of substrata

_____21. Pollution (specify type)

_____22. Shoreline erosion

_____23. Other

Table 3.2-1. Fish and Wildlife Service checklist of potential environmental **alterations resulting from dredge and fill** activities (from Hubbard and **Blair 1979).**

II. Environmental Impacts	Yes	Maybe	No
1. Water. Will the proposal result in:			
a. Changes in currents, or the course or direction of water movements, in fresh waters?	____	____	____
b. Changes in absorption rates, drainage patterns, or the rate and amount of surface water runoff?	____	____	____
c. Alterations to the course or flow of flood waters?	____	____	____
d. Change in the amount of surface water in any water body?	____	____	____
e. Discharge into surface waters, or in any alteration of surface water quality, including but not limited to temperature, dissolved oxygen, or turbidity?	____	____	____
f. Change in the quantity of ground waters, either through direct additions or withdrawals, or through interception of an aquifer by cuts or excavations?	____	____	____
g. Deterioration in ground water quality, either through direct injection, or through the seepage of leachate, phosphates, detergents, waterborne virus or bacteria, or other substances into the ground water?	____	____	____

Table 3.2-2. Part of a checklist used by the U.S. Fish and Wildlife Service to assess impacts of dredging and filling projects (from Hubbard and Blair 1979).

Impact	Anticipated Magnitude of Impact		
	Very severe	Moderately severe	Less severe
A. Ground water quality			
Factors			
1. Leachate production and potential migration to ground water	______	______	______
2. Water table fluctuations which can result in leachate production	______	______	______
3. Intense or extended precipitation resulting in leachate production	______	______	______

Table 3.2-3. Part of a scaling checklist used to assess impacts of upland disposal of dredged materials (from SCS Engineers 1977).

Classes of Factors in Level of Adverse Impact	Individual Factors for Consideration	Factor[1] Scale (0-3)	Factor[2] Weight (1-5)	Scaling-[3] Weighting Product (0-15)
Type of operations:				
• GENERAL NATURE	Maintenance, continuation of existing work, or new work?	____	____	____
	Open water, wetland, or confined upland[4] disposal?	____	____	____
	Dredging or excavating,[4] fill, or spoil disposal?	____	____	____
• STRUCTURAL FEATURES	Temporary roads, pipelines, navigation channels, or stream diversions?	____	____	____
• DREDGING[4] AND DISCHARGE EQUIPMENT	Mechanical or hydraulic equipment?	____	____	____
	Potential overflow or handling discharge?	____	____	____
• TRANSPORTATION ROUTES AND EQUIPMENT	Hopper dredges, barges, pipelines, or trucks?	____	____	____
	Open water, wetland or upland routes?	____	____	____
Scale of operations:				
• STRUCTURAL FEATURES	How extensive is road, pipeline, channel, dike, dam and bulkhead construction?	____	____	____
• TRANSPORTATION[4]	What transportation distances?[4]	____	____	____
	What volume of truck or barge traffic or pipeline transport?	____	____	____
• MATERIAL PLACEMENT	What surface area and average depth of material removal[4] or placement?	____	____	____
	What average or maximum change in substrate or soil excavation?	____	____	____
	What portion of a productive, sensitive or unique area affected?	____	____	____
Timing of operations:				
• DURATION	Long-term and continuous or short-term and periodic or seasonal?	____	____	____
• SCHEDULING	Are critical periods or seasons avoided (heavy rain, wind or waves, low flows; migration, spawning, nesting, and rearing)?	____	____	____
	SUBTOTALS	____	____	____

1. Level of impact for each factor is scaled insignificant (0), minor (1), moderate (2), or major (3).
2. Factor weight from low (1) to high (5) is assigned based on relative importance of each factor.
3. Scale value is multiplied by numerical weight.
4. Not explicitly covered under Section 404 of Clean Water Act.

Table 3.2-4. Assessment scale-weighting checklists for type, scale, and timing factors associated with dredge and fill activities (Nelson and Associates Inc., 1981).

vant to facilities planning); (3) the matrix analysis centers not on interpretation of impacts but merely on impact identification; and (4) evaluation consistency may vary between persons conducting the analysts.

A variety of matrix types has been developed. These include: (1) descriptive/interaction types; (2) scaling and scale-weighted types; and (3) stepped matrices. An example of the descriptive matrix method is given in Table 3.2-5. In this method (Yorke 1978), the first descriptive matrix relates various project activities to physical-chemical impacts. A second matrix is then used to translate these into biological impacts. The impacts are described verbally in all cases (although the USFWS may ultimately develop a quantitative means of conducting this analysis). In the interactive matrix (Figure 3.2-1) potential impacts associated with project features are cross-referenced with bullets. In the scaling type matrix (Figure 3.2-2), project activities are rated with respect to their potential to produce impacts. In this method, impacts at alternate sites can be effectively compared with a single format. Scale-weighted matrices can be used to assign an indication of the magnitude and relative importance of various impacts (Figure 3.2-3). The advantage of this method is that trade-offs of various alternatives are identified effectively (Holling 1978). The method also distinguishes between impact magnitude and importance (Greenberg et al. 1978).

In the stepped matrix approach, a series of interlinked impact matrices are used to analyze chains of interactive, physical, chemical and biological events (the Yorke method discussed above is actually a two-generation stepped matrix) (Yorke 1978). Because the Yorke method derives impacts based on scientific literature and formally catalogs this information, it has been cited as being more objective than other matrix methods. Trial et al. (1980) adopted and modified this method as a water resource planning tool. The method can also be used to predict long-term "chain" reaction impacts, an advantage directly relating to 201 projects. Nelson et al. (1982c) produced a dual matrix for use in 404 related projects (Figures 3.2-4 and 3.2-5).

PHYSICAL-CHEMICAL CHARACTERISTIC	ASSOCIATED IMPACT
Depth and Stage	Channel enlargement eliminates the diversity of water depths associated with natural meandering channels. Pools and riffles are replaced by uniformly deep or uniformly shallow reaches of channels. Enlarged channels will carry a greater percentage of flow during floods which will reduce the depth and duration of flood plain overflow. If the channels are deepened, stages will be lowered during dry periods which will promote the drainage of adjacent wetlands.
Water Surface Area	Deepening will create nearly uniform surface areas throughout the year. The shallow water zone near the banks which is exposed during dry periods and inundated during wet periods will be reduced in area. Widening will increase surface area and the variability of water surface area. Spoil areas resulting from the excavations will reduce the flood plain area subject to periodic flooding.
Channel Configuration	Enlargement will create uniform conditions. Pools, riffles, undercut banks, and other diverse habitats will be eliminated.
Water Velocity	Mean water velocities will be reduced because of an increase in cross-sectional area. Velocities will be more uniform throughout the cross section. Areas of high and low velocity will be eliminated.
Temperature	Widening will increase water temperature and the range of temperatures because of the greater water surface area, the reduced velocity, and the elimination of shade by removal of stream bank vegetation. These actions increase the effect on insolation. Deepening will have minimal impact on temperature as long as stream bank vegetation is not disturbed. Disposal of excavated or dredged material in the adjacent flood plains will increase water temperature because stream-side vegetation is usually removed or destroyed by the construction equipment or suffocated by the deposits.
Suspended Solids	The construction phase of channel enlargement will increase the concentration and discharge of suspended solids at the site and downstream. This will increase the rate of sediment deposition in the channel and/or flood plain at downstream sites. Sediment discharge will decrease after construction, but it may persist at higher than normal levels for a number of years as the stream channels adjust to new flow regimes. Reaches of deepened channels may become sinks and aggrade rapidly with fine sand and silt.

Table 3.2-5. Descriptive matrix illustrating physical and chemical impacts of river channel dredging (enlargement) (from Yorke 1978).

PHYSICAL-CHEMICAL CHARACTERISTIC	ASSOCIATED IMPACT
Bed Material	Both widening and deepening will disrupt the equilibrium of the stream channel and the bed material and create a period of constantly changing bed conditions. Deepening will remove the armor layer of the stream bed, which will cause an increase in bed material movement until large particles restabilize the surface. Channel widening may increase bed load as additional fine bed material is available for transport or it may decrease the bed load and cause deposition because the increased cross-sectional area severely reduces the competence of the channel for transporting bed material. Removal of organic material from the bed will reduce both food sources and the diversity of substrates available to benthic organisms. Removal of stream-side vegetation during construction may reduce substantially the source of detritus that is added to the system annually.
Dissolved Substances	Construction will increase the total dissolved solids eroded from newly exposed soils. Nutrients, pesticides, heavy metals, and other substances that were bound to bottom sediments may be released to the system. The disturbances of organic bed material and the release of nutrients may increase the biochemical oxygen demand and cause oxygen deficiencies downstream. Enlargement, particularly deepening, may promote increase in agricultural drainage and concomitant increases in salts, nutrients, and pesticides with surface runoff. Increased channel capacity will reduce overflow and the use of the flood plain for assimilation of organic nutrients and wastes.
Light Transmissivity	Construction activities will reduce light transmissivity at the site and at downstream locations because of increased sediment loads. This condition may persist for many years as stream banks adjust to new flow regimes. A more efficient channel and ancillary drains will increase runoff and the silt and clay loads which will reduce light transmissivity.
Flow Variability	The range in water discharge will increase. Peak flows will be higher and low flows will be lower. Improved channel conveyance will cause flood waters to move quickly through enlarged channels and concentrate at some point downstream. This results in higher peak discharges and a shorter duration of flooding. Deepening a channel will increase drainage from adjacent flood plains, which will increase the rate of ground water discharge and decrease the amount of water available to sustain base flow during dry periods. The deepened channel also may penetrate through an impermeable or semi-impermeable layer beneath the stream bed, resulting in dewatering the channel as water is discharged to the ground water system.

Table 3.2-5. Descriptive matrix illustrating physical and chemical impacts of river channel dredging (enlargement) (from Yorke 1978) (concluded).

	ACTIVITIES ENVIRONMENTAL EVENTS	1. Liquid Waste Disposal	2. Gaseous Waste Disposal	3. Solid Waste Disposal	4. Offshore Construction	5. Coastal Construction	6. Inland Construction	7. Land Canals	8. Offshore Channels	9. Dredging and Spoil Disposal	10. Excavation	11. Drainage	12. Filling	13. Draining	14. Well Development	15. Devegetation	16. Traversing With Vehicles	17. Fertilizers/Biocides
WATER QUALITY	1. BOD	●		●	●	●	●			●		●		●		●	●	●
	2. Dissolved Oxygen	●		●	●	●	●			●		●		●		●	●	●
	3. Nutrients	●		●						●		●		●		●		●
	4. Pathogens	●		●								●						
	5. Floatables	●		●								●		●			●	
	6. Odors and Tastes	●		●						●		●		●			●	
	7. Color	●		●						●		●		●			●	
	8. Toxicity	●		●	●					●		●					●	●
	9. Dissolved Salts	●		●		●		●	●	●		●		●	●			
	10. Suspended Solids	●		●	●	●	●	●	●	●	●	●	●	●		●	●	
	11. Radiological	●		●								●						
	12. Temperature	●						●	●	●		●		●				
	13. pH Buffering	●		●						●		●		●				
	14. Ground Water	●		●			●	●			●	●	●	●	●	●		●
AIR QUALITY	15. Particulates	●	●	●													●	●
	16. Gases	●	●	●													●	
PHYSICAL PROCESSES	17. Erosion	●			●	●	●	●	●	●	●	●	●	●		●	●	
	18. Deposition and Accretion	●			●	●	●	●	●	●	●	●	●	●		●	●	
	19. Subsidence													●	●			
	20. Hydraulics	●		●	●	●	●	●	●	●		●	●	●		●		
	21. Devegetation	●	●	●		●	●	●	●	●	●	●	●	●		●	●	●
	22. Infiltration	●		●			●	●		●	●	●	●	●	●	●		
	23. Ponding			●			●	●		●	●	●						
BIOLOGICAL PROCESSES	24. Photosynthesis	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	25. Consumers/Food Chain	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	26. Decomposition	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●
	27. Predation	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●	●

Figure 3.2-1. Interaction matrix linking project activities with associated environmental elements or effects (Texas Department of Water Resources 1977).

	Study Area	Site #1				Site #2			
Project Activity of Impact	Evaluative Parameter	Current Parameter Value	Projected Parameter Value	Habitat Affected	Impact Severity	Current Parameter Value	Projected Parameter Value	Habitat Affected	Impact Severity
Dredging	Depth (ft)	8-12	25	• Lake • Sand Bar Mud Flats	1 3	12	40	• Stream Channel • Wetlands • Beach or Banks	2 3 2
Channel Widening and Straightening	Extent (ft) and Bank Habitat	0	0	None	0	100	140	• Banks	2
Pier and Piling Construction	Area (sq ft) and Habitat Affected	0	300	• Lake	0	0	0	None	0
Road Construction	Length (ft) and Habitat Affected	0	100 (dirt)	• Uplands	0	0	0	None	0
Increased Turbidity	Suspended Solids (mg l)	Low	Medium	• Lake	1	Medium	High	• Stream Channel • Lake	2 1
Nutrient Loading	Nitrate and Phosphate Levels (mg l)	Low	Medium	• Lake	1	Low	High	• Stream Channel • Lake	2 2

Key
-1 Beneficial
0 No impact
1 Slight detriment
2 Significant adverse impact
3 Severe adverse impact

* Impact severity will be evaluated based on guidelines for each parameter associated with a given habitat type.

Figure 3.2-2. Impact severity matrix for scaling comparative impacts at two alternative sites for marina construction (from Nelson et al. 1977).

INSTRUCTIONS

1. Identify all actions (located across the top of the matrix) that are part of the proposed project.

2. Under each of the proposed actions, place a slash at the intersection with each item on the side of the matrix if an impact is possible.

3. Having completed the matrix, in the upper left-hand corner of each box with a slash, place a number from 1 to 10 which indicates the MAGNITUDE of the possible impact: 10 represents the greatest magnitude of impact and 1, the least (no zeroes). Before each number place + if the impact would be beneficial. In the lower right-hand corner of the box place a number from 1 to 10 which indicates the IMPORTANCE of the possible impact (e.g. regional vs. local): 10 represents the greatest importance and 1, the least (no zeroes).

4. The text which accompanies the matrix should be a discussion of the significant impacts, those columns and rows with large numbers of boxes marked and individual boxes with the larger numbers.

SAMPLE MATRIX

	a	b	c	d	e
a		2/1			8/5
b		7/2	8/8	3/1	9/7

			A. MODIFICATION OF REGIME												
		PROPOSED ACTIONS	a. Exotic flora or fauna introduction	b. Biological controls	c. Modification of habitat	d. Alteration of ground cover	e. Alteration of ground water hydrology	f. Alteration of drainage	g. River control and flow modification	h. Canalization	i. Irrigation	j. Weather modification	k. Burning	l. Surface or paving	m. Noise and vibration
PHYSICAL AND CHEMICAL CHARACTERISTICS	1. EARTH	a. Mineral resources													
		b. Construction materials													
		c. Soils													
		d. Land form													
		e. Force fields and background radiation													
		f. Unique physical features													
	2. WATER	a. Surface													
		b. Ocean													
		c. Underground													
		d. Quality													
		e. Temperature													
		f. Recharge													
		g. Snow, ice and permafrost													

Figure 3.2-3. Portion of Leopold interaction matrix with instructions for scaling and weighting impacts (from Greenberg et al. 1978).

Dredge or Fill Project Activity	Physical Effects											Chemical Effects					
	● Increased turbidity	● Increased sedimentation	● Fluid mud deposit	● Substrate/soil burial	● Particulate mismatch	● Increased erosion	● Altered elevation/gradients/contours	● Altered water levels/fluctuations	● Altered currents/circulation	● Altered flow regime	● Altered temperature regime	● Excess nutrient release	● Toxic contaminant release	● Oxidized contaminant leaching	● Contaminant migration	● Increased BOD/COD	● Altered pH/DO/nutrient balance
DREDGING																	
● Navigation channels																	
● Drainage channels																	
● Irrigation channels																	
● Stream channelization																	
● Stream diversion																	
● Pipeline construction																	
● Port/marina construction																	
● Placer mining																	
SPOIL DISPOSAL																	
● Upland--contained																	
● Open water/wetland--contained																	
● Open water/wetland--uncontained																	
FILLING																	
● Landfills, bulkheading																	
● Road/bridge construction																	
● Dam/dike/levee construction																	
● Causeway/jetty construction																	
● Bank/shore protection																	
● Marsh/island development																	

Figure 3.2-4. Matrix for linking dredge and fill activities with physical and chemical effects (from Nelson and Associates Inc. 1981).

	Physical Effects											**Chemical Effects**					
	● Increased turbidity	● Increased sedimentation	● Fluid mud deposit	● Substrate/soil burial	● Particulate mismatch	● Increased erosion	● Altered elevation/gradients/contours	● Altered water levels/fluctuations	● Altered currents/circulation	● Altered flow regime	● Altered temperature regime	● Excess nutrient release	● Toxic contaminant release	● Oxidized contaminant leaching	● Contaminant migration	● Increased BOD/COD	● Altered pH/DO/nutrient balance
Ecosystem/Community Effects																	
● Reduced photosynthesis																	
● Reduced nutrient cycling																	
● Increased toxic bioaccumulation																	
● Reduced productivity																	
● Impaired sight-feeding																	
● Impaired respiration																	
● Impaired reproduction																	
● Lower disease resistance																	
● Increased pathogens																	
● Increased predators																	
● Loss of critical/preferred food sources																	
● Loss of escape cover																	
● Reduced species abundance/ diversity																	
● Reduced stability/resiliency																	
Population Effects																	
● Smothering or burial																	
● Forced migration/recolonization																	
● Disrupted spawning/nesting/ breeding																	
● Disrupted rearing/migration/ wintering																	
● Loss of vegetation																	
● Loss of benthos/fish																	
● Loss of waterfowl/amphibians																	

Figure 3.2-5. Matrix for linking physical-chemical effects of dredge and fill projects with adverse biological effects (from Nelson and Associates Inc. 1981).

3.2.3 Networks

In a network, sequential relationships between project activities and subsequently, physical, chemical and biological effects, are established. In essence, the network is an expanded matrix, but the network analysis allows cumulative impacts to be analyzed (Jain et al. 1981). The primary advantage of network analysis is that it can be used to show how several impacts are produced by individual actions (Golden et al. 1979). However, networks also tend to become too large and confusing (Duke et al. 1977).

Three general types of network methods include: (1) food webs; (2) energy transfer models; and (3) analytical networks (including "decision trees"). Foodweb models (Figures 3.2-6, 3.2-7, and 3.2-8) may be either in pictorial or diagrammatic form. While these would be useful in depicting baseline conditions in wetlands or other community types, they would be of limited value for detailed impact analysis. The analytical network (Figures 3.2-9, 3.2-10 and 3.2-11) are an effective means of determining cause-and-effect relationships between project activities and interrelated impacts. They can also be used as an effective means to analyze secondary and tertiary (terms here used to define chain reaction impacts and not induced growth impacts) effects (Figure 3.2-11). A decision tree utilizes a dichotomizing "yes/no" key to determine impacts (Figure 3.2-12). The decision tree may be used to ensure that exhaustive coverage of all project impacts is achieved and as a means of flagging potentially important and major issues surrounding project implementation.

3.2.4 Mapping

Various methods are available in which mapping can be used to analyze impacts on water resources including watersheds, wetlands, and aquatic ecosystems. The advantages of using mapping for conducting impact analysis include: (1) the ability to depict spatial distribution of impacts; (2) ability to depict habitat types, sensitive areas (i.e., wetlands) or key resources; and (3) ability to compare projected impacts of various project alternatives. Specific mapping techniques include: (1) habitat classification and ecological maps; (2) analytical overlays; and (3) photo-interpretation.

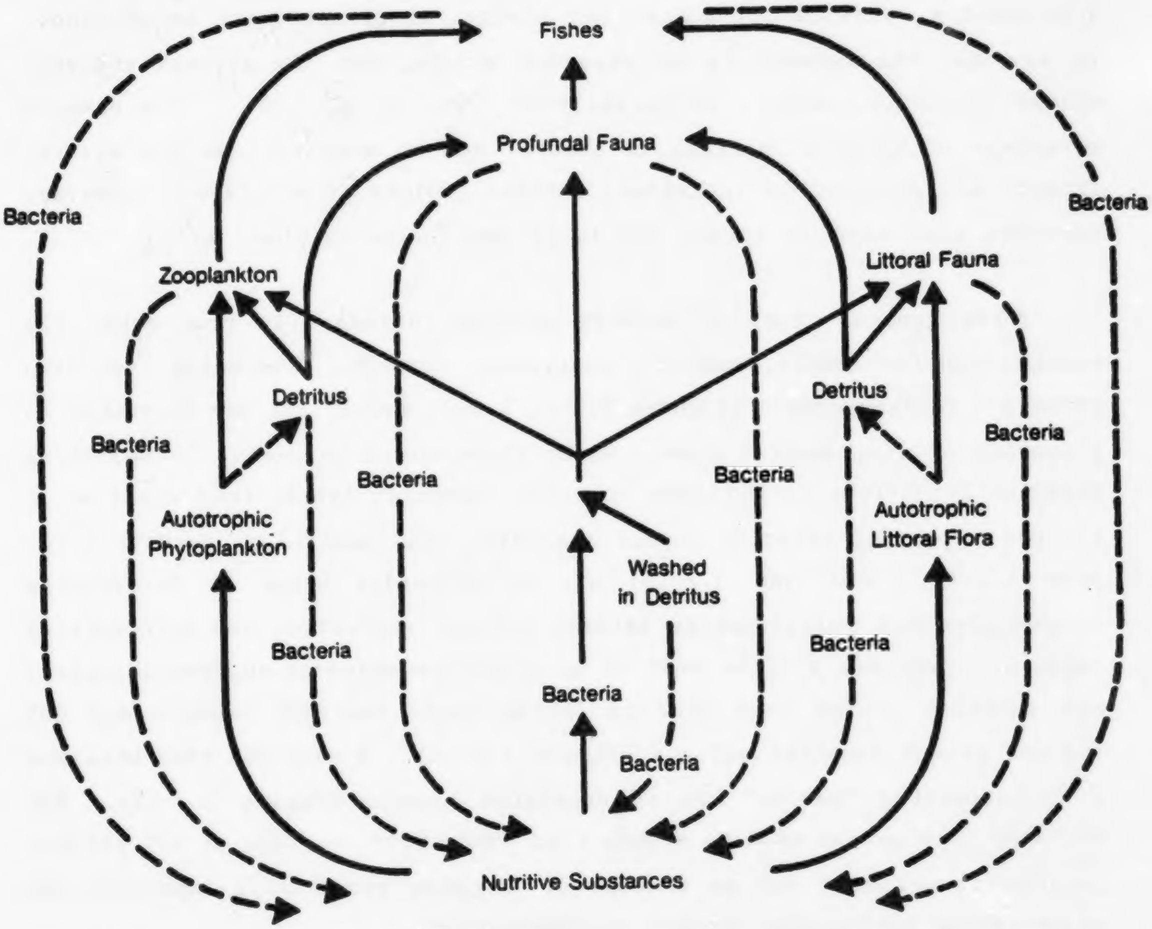


Figure 3.2-6. Diagram of a freshwater aquatic food web (from Welch 1952).

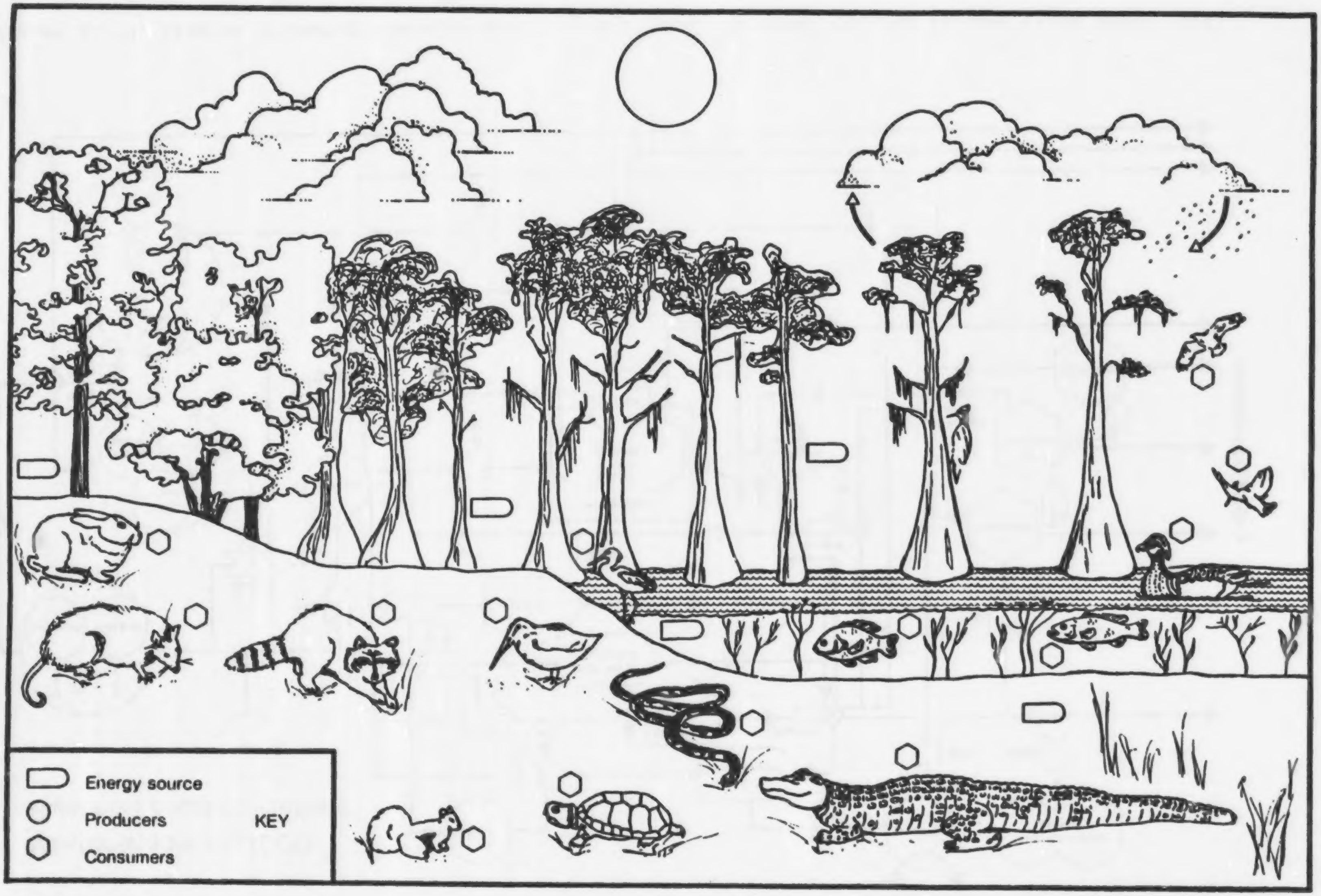


Figure 3.2-7. Pictorial diagram of energy transfer in a typical riverine forested wetland (from USFWS 1977).

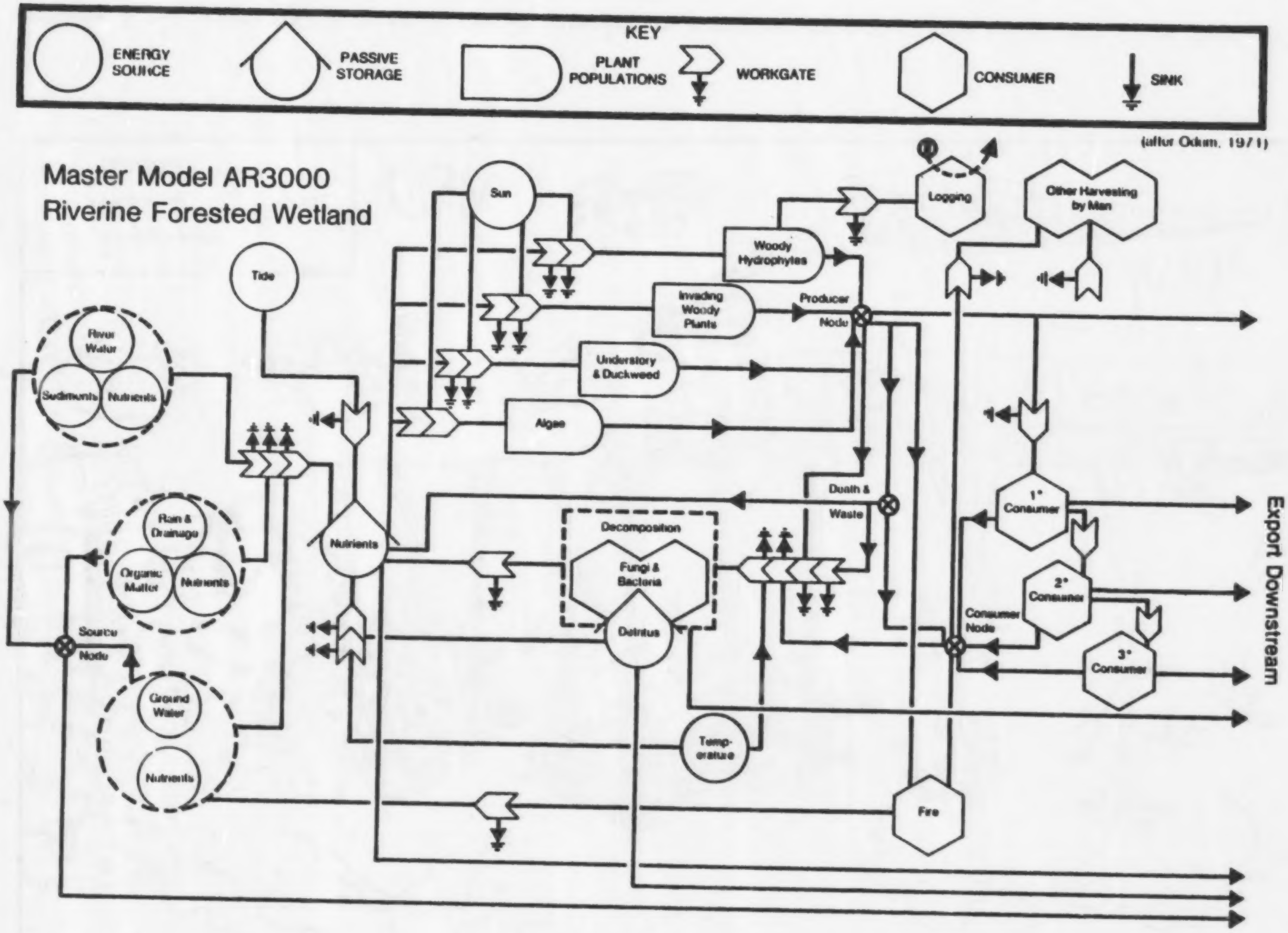


Figure 3.2-8. Diagram of energy transfer model for a typical riverine forested wetland (from USFWS 1977).

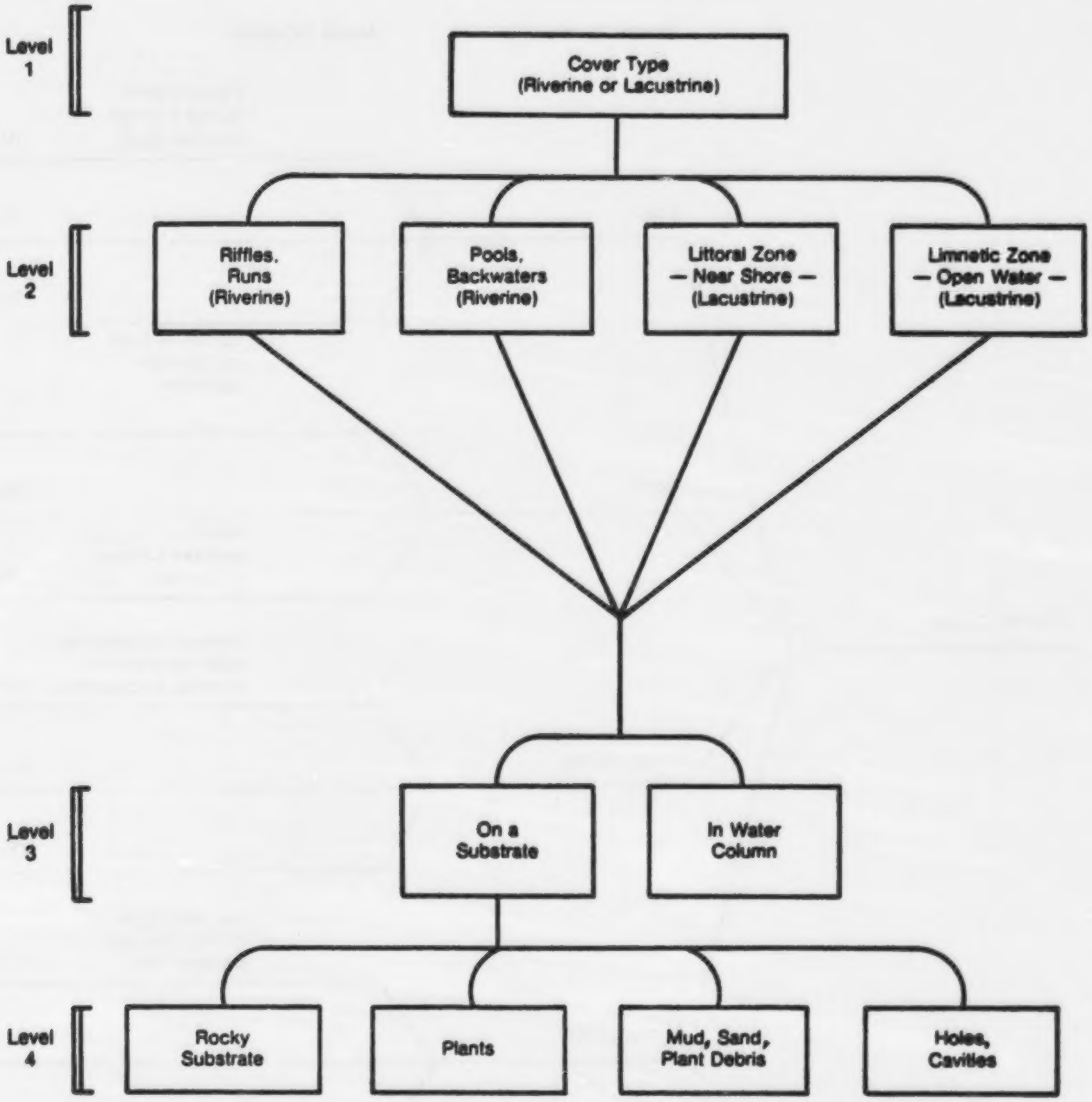
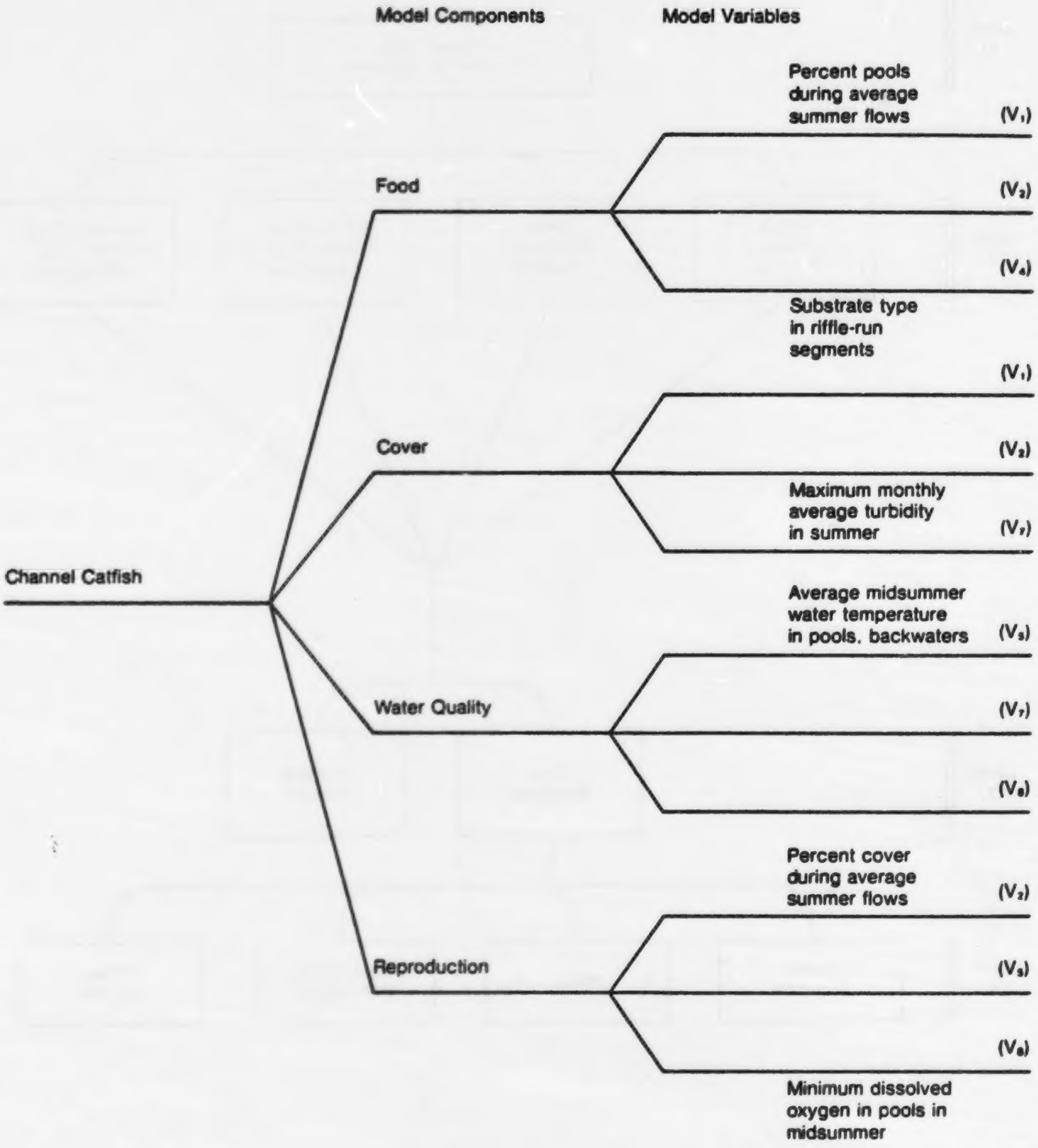

Level 1
Cover Type (Riverine or Lacustrine)
Level 2
Riffles, Runs (Riverine)
Pools, Backwaters (Riverine)
Littoral Zone — Near Shore — (Lacustrine)
Limnetic Zone — Open Water — (Lacustrine)
Level 3
On a Substrate
In Water Column
Level 4
Rocky Substrate
Plants
Mud, Sand, Plant Debris
Holes, Cavities

Figure 3.2-9. Network illustrating various habitat components for a riverine or lacustrine cover type at four levels (from USFWS 1980).



Model Components
Model Variables
Percent pools during average summer flows
(V₁)
Food
(V₂)
(V₄)
Substrate type in riffle-run segments
(V₁)
Cover
(V₂)
Maximum monthly average turbidity in summer
(V₇)
Channel Catfish
Average midsummer water temperature in pools, backwaters
(V₃)
Water Quality
(V₇)
(V₈)
Percent cover during average summer flows
(V₂)
Reproduction
(V₃)
(V₈)
Minimum dissolved oxygen in pools in midsummer

Figure 3.2-10. Network diagram of relationships among components of a channel catfish habitat suitability model (from USFWS 1980).

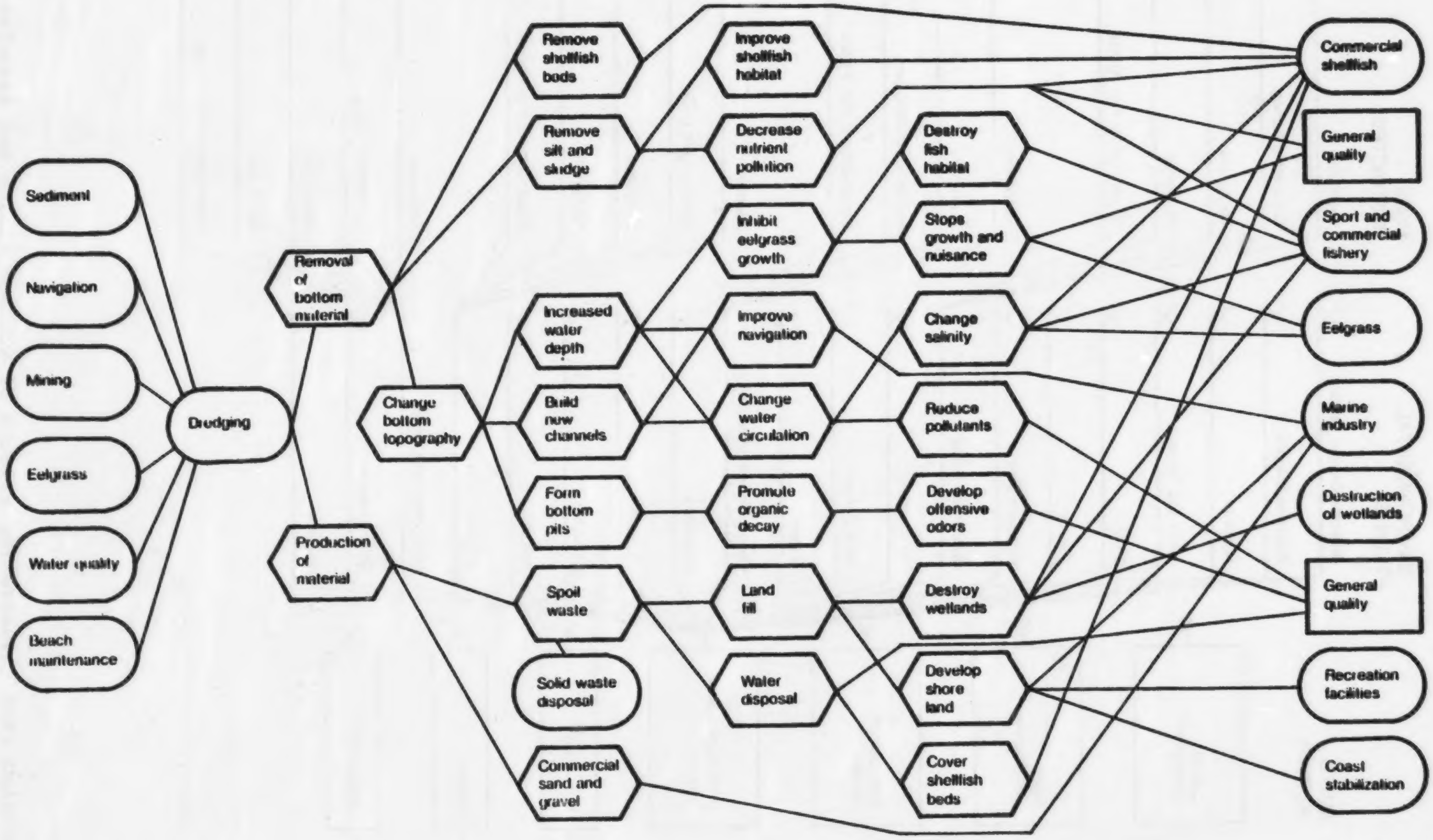


Figure 3.2-11. Network analysis of the sequential effects of a dredging project on coastal ecosystems (from Canter et al. 1977).

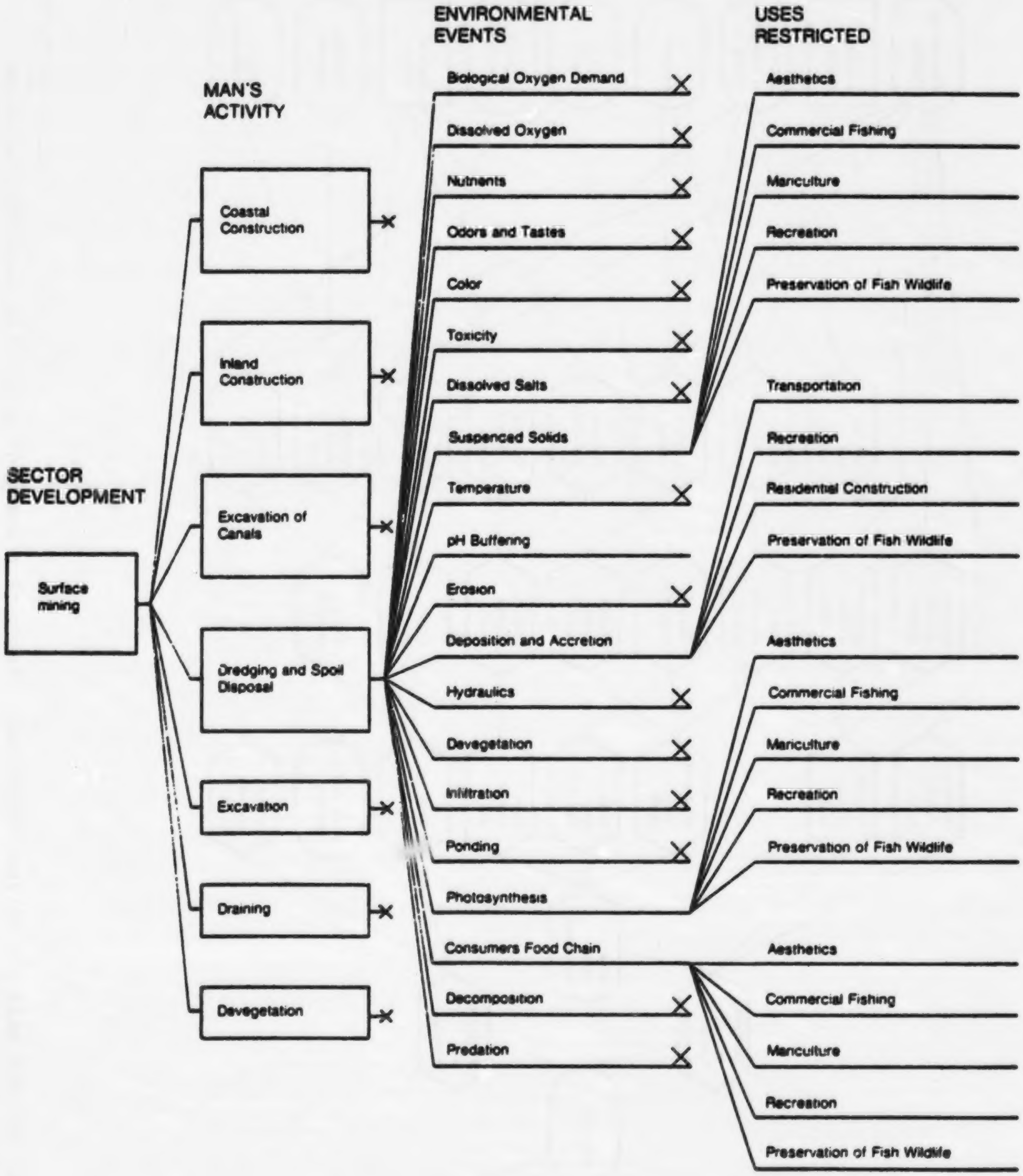


Figure 3.2-12. Decision tree illustrating effects of surface mining and associated dredging and filling (Texas Department of Water Resources 1977).

Maps are a particularly good means of depicting habitat types and project-related effects on existing natural habitats. An example is shown in Figure 3.2-13, in which two alternate sites for a proposed marina are depicted. The effects of each plan on existing wetlands can easily be seen from this map. The USFWS has recently developed a habitat classification scheme that can be used in defining wetlands in USEPA Region V (Lonard _et al_. 1981) (Figure 3.2-14). An example of the application of this system by the USFWS National Wetland Inventory is shown in Figure 3.2-15. Figure 3.2-16 is an illustration of one of the major USFWS habitat types as presented in Cowardin _et al_. (1979). Ecological "key" maps are also available and can be used to depict wetland or other resources within a larger geographical area (Figure 3.2-17). However, these may be prepared at a smaller scale. Key maps are useful because they identify major important resources within a given (large) geographic area in a small amount of text. Such a map could prove valuable in conducting cumulative impact analyses.

Map overlay techniques have been used for many years as an impact evaluation technique. In this method, mylar overlays of either baseline conditions or project alternatives are superimposed on a base map. For example, baseline distribution of wetland types within a facilities planning service area could be prepared on one overlay. Impacts of alternative interceptor configurations could then be determined by superimposing areas of projected induced growth on the existing wetland distribution, thereby illustrating which areas would be affected either directly (habitat elimination) or indirectly (i.e., urban runoff, etc...). Methods of mapping environmental resources of all types (including wetlands) with the aid of a computer are available through the USFWS (USFWS 1979). These include digitizing geographic information through the Wetland Analytical Mapping System (WAMS), and an interactive system called Map Overlay and Statistical System (MOSS) (however, these systems require an existing data base which is not yet complete for the midwest). The USEPA's EPIC laboratories also provide a means of mapping wetlands using color and color infra-red photography. The State of Wisconsin will have mapped all of that state's wetlands at a scale of 1:24,000 (1 inch = 2,000 feet) by 1 July 1983 (Figure 3.2-18).

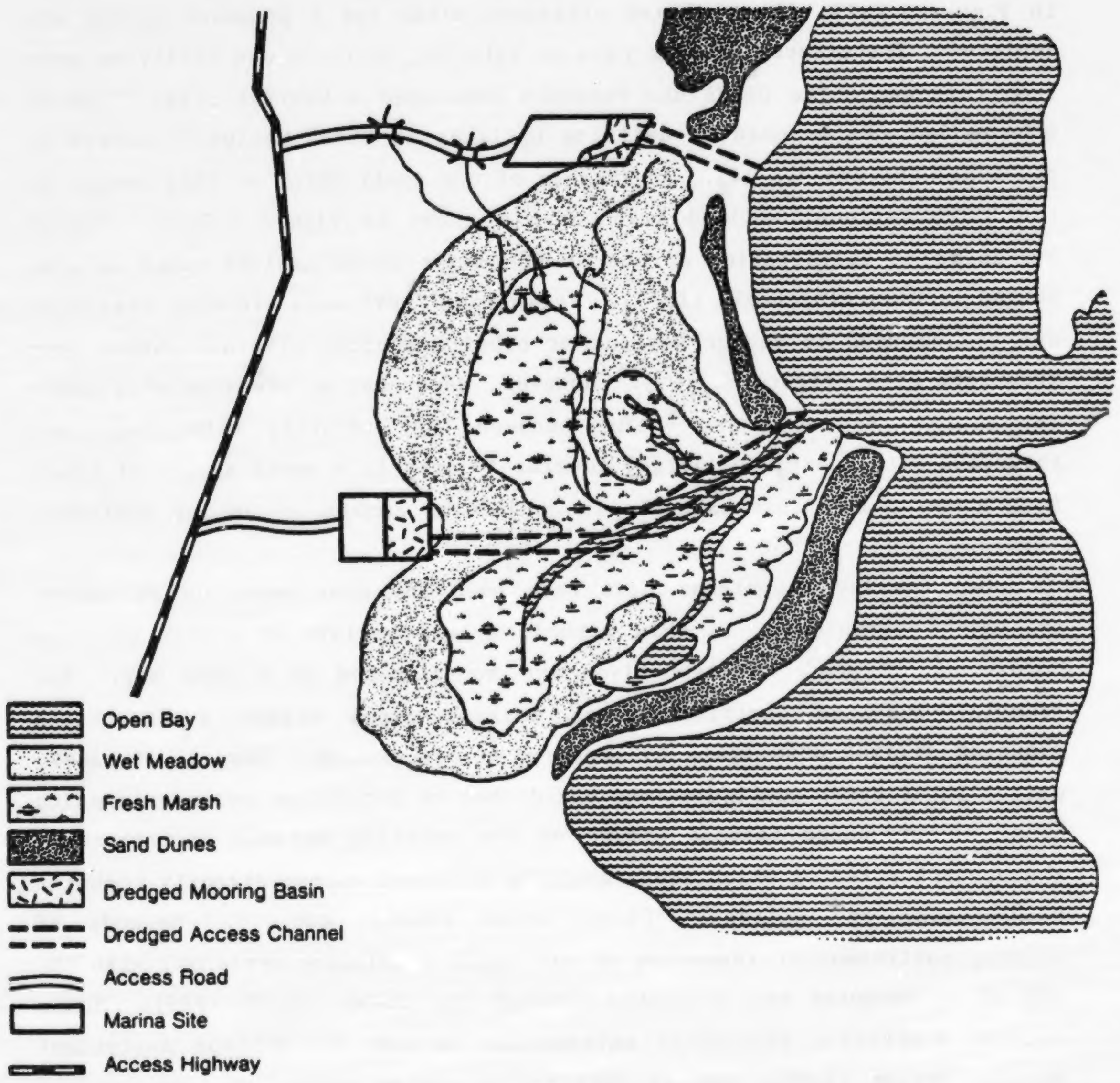


Figure 3.2-13. Map of a wetland area under consideration for construction of a marina involving channel dredging and mooring basin at two alternative sites (in Nelson et al. 1982c, adapted from Reppert et al. 1979).

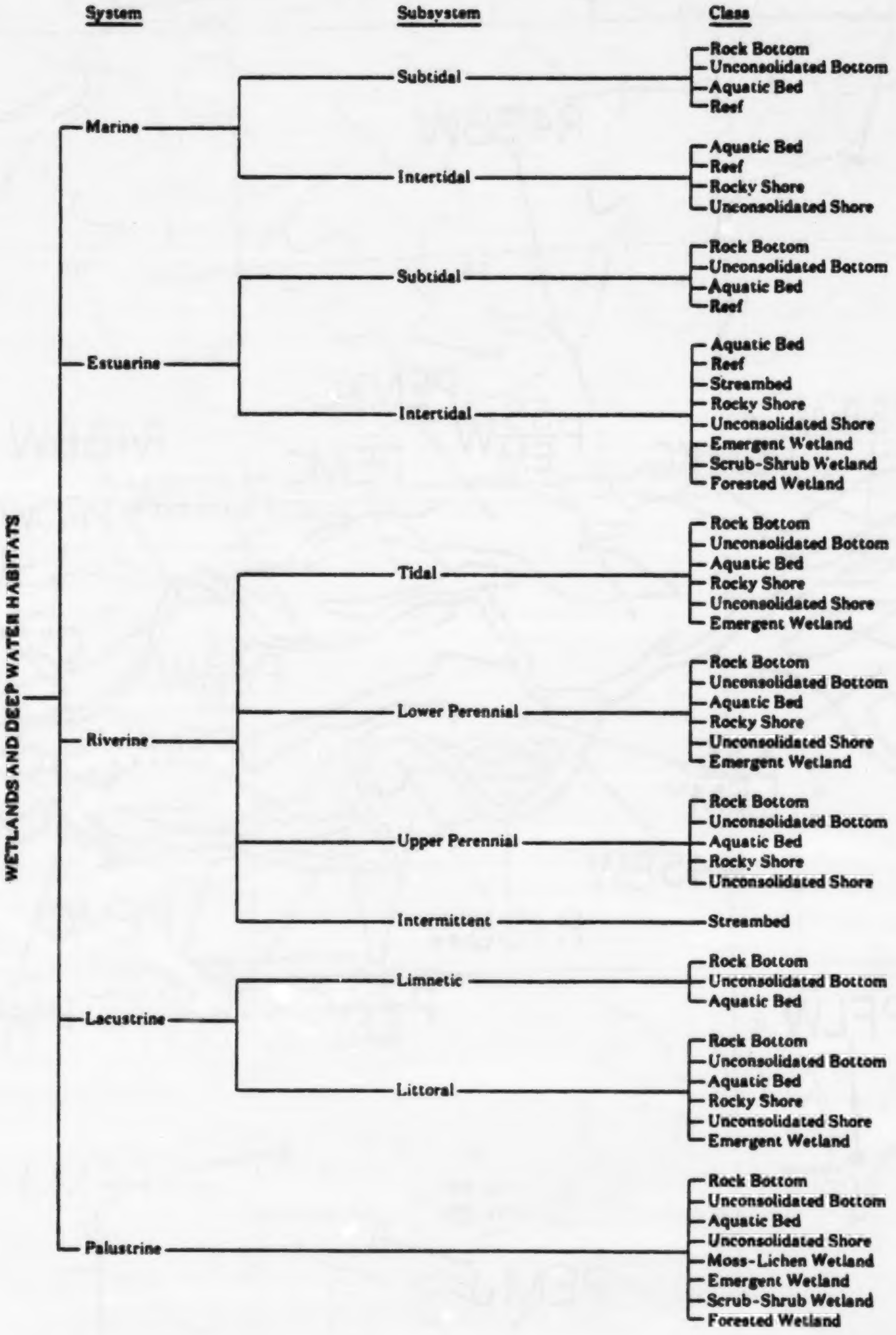


Figure 3.2-14. U.S. Fish and Wildlife Service National Wetlands Inventory classification scheme (from Cowardin et al. 1979).

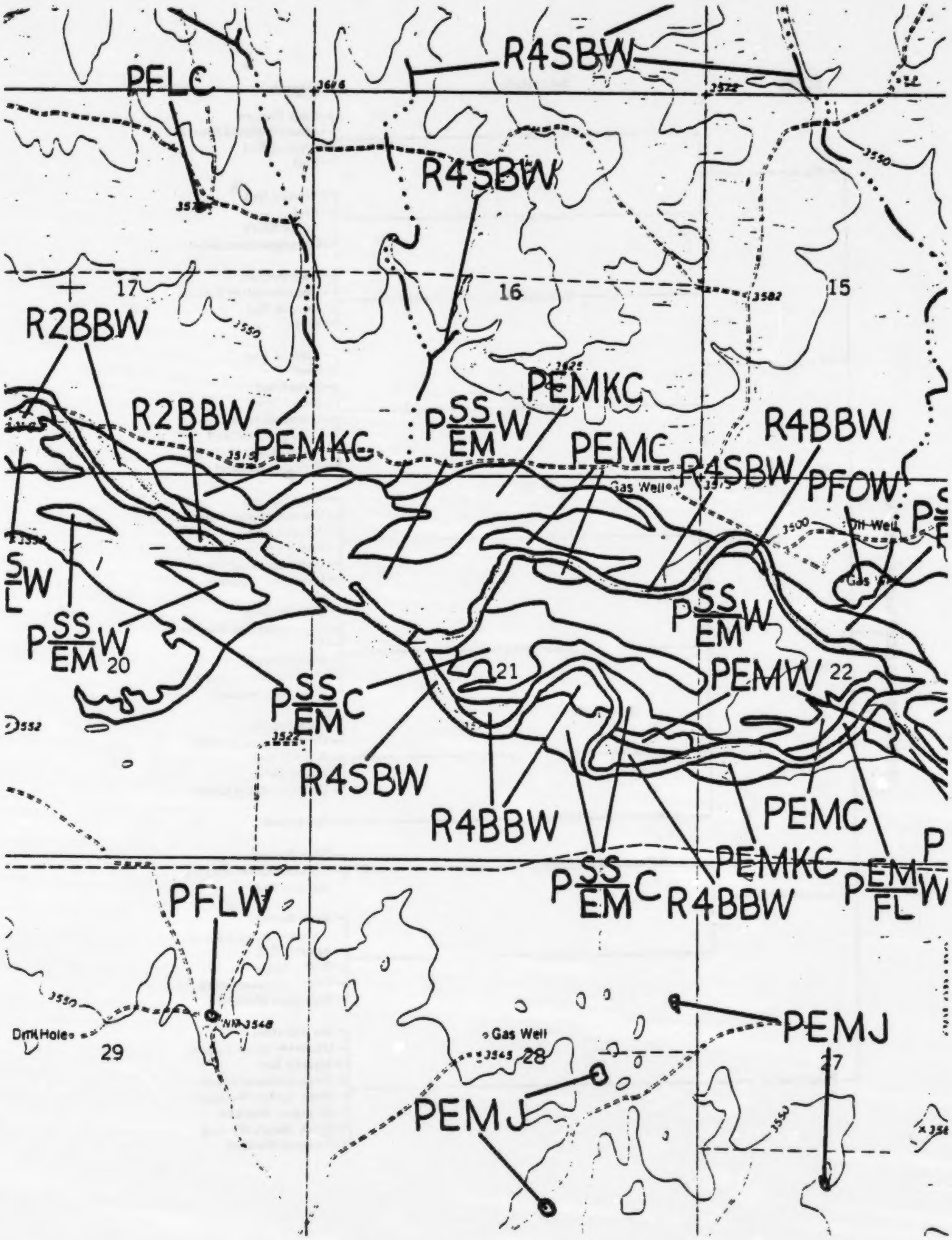


Figure 3.2-15. Sample from a 1:24,000 scale habitat classification map showing wetlands in Colorado (from USFWS National Wetlands Inventory)

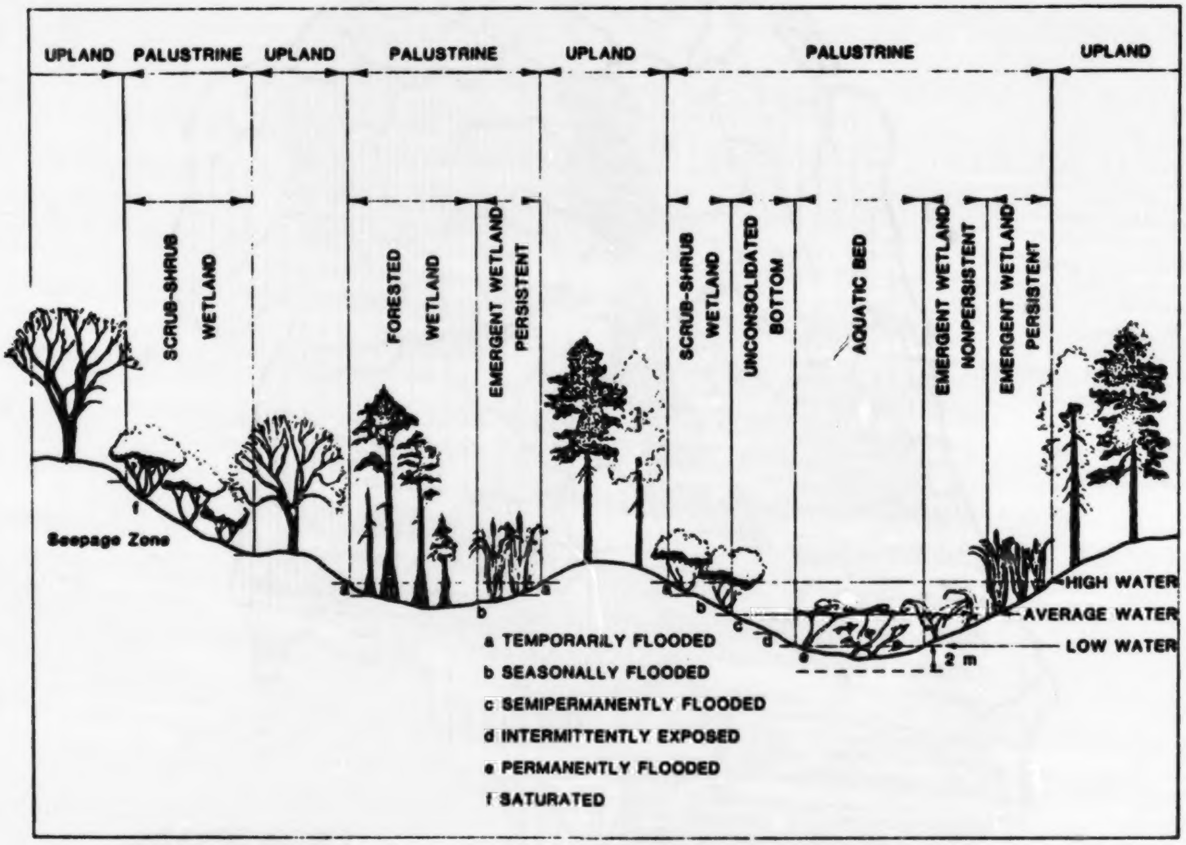


Figure 3.2-16. Features of the "palustrine" wetland system- part of the wetland classification scheme used by the U.S. Fish and Wildlife Service (from Cowardin et al. 1979).

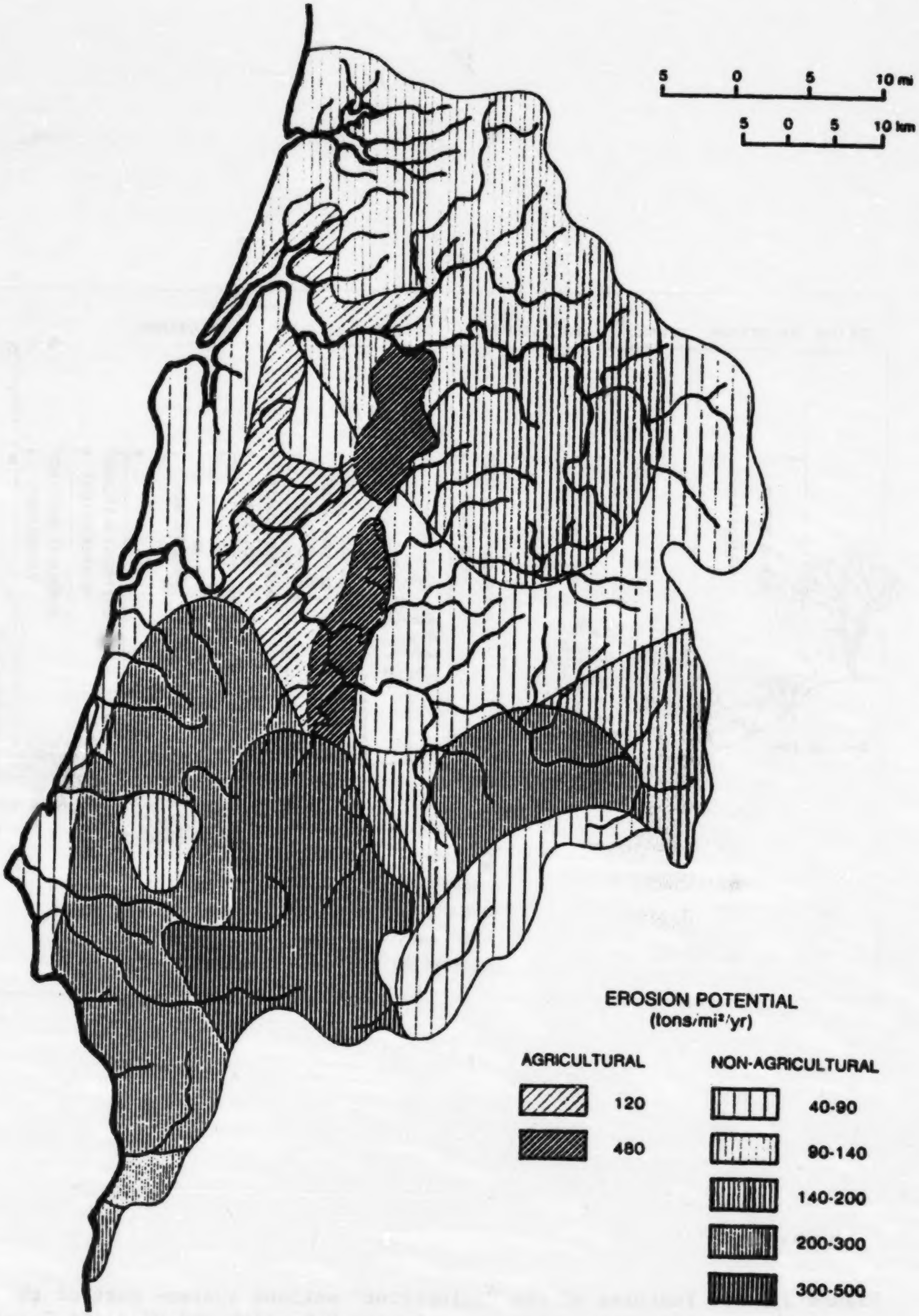


Figure 3.2-17. Ecological "key" map illustrating erosion potential for a northwest coastal area watershed (from Proctor et al. 1978).

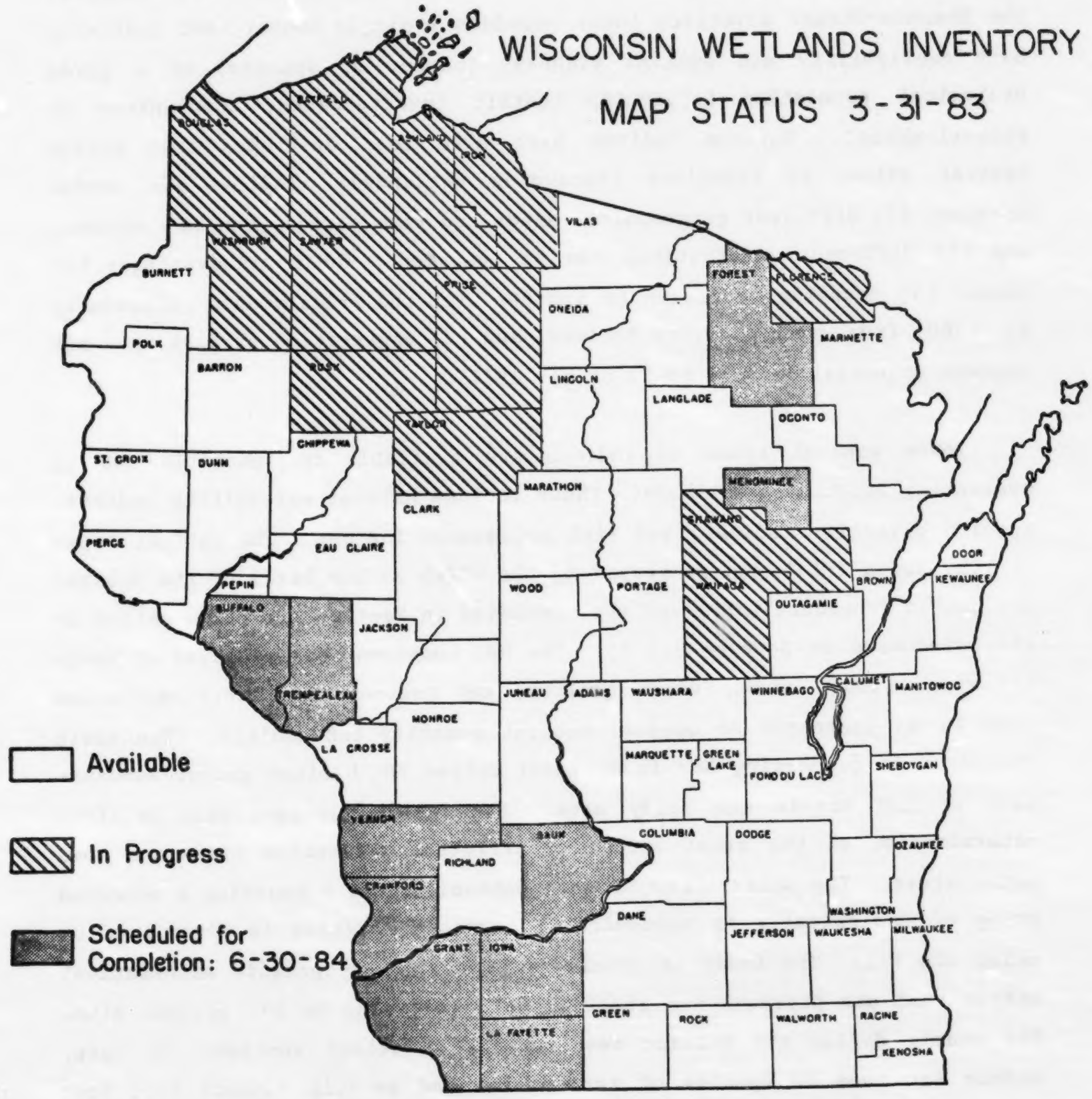


Figure 3.2-18. Areas of Wisconsin in which wetlands have been or are currently being mapped (from WDNR 1982).

3.2.5 Indices

An index is defined as any combination of individual arithmetic measurements (usually of varying characteristics) that allows for an overall description of the value or nature of a natural phenomonon. For example, the Shannon-Wiener diversity index provides a single number that indicates both equitability and species richness (number of species) of a given biological population (typically benthic invertebrates, zooplankton or phytoplankton). Various indices have also been developed that define habitat values or functions (including wetlands). Indices are useful because: (1) different geographical areas and time periods can be compared; and (2) different alternatives can be compared. Their disadvantages include: (1) possible confusion of indices with the primary data (Simpson et al. 1960) from which they are derived; and (2) aggregation of data that may conceal potential impacts (Duke et al. 1977).

Three general types of indices are available for possible use in evaluating impacts on wetlands. These include habitat suitability indices, species diversity indices, and risk assessment indices. The Habitat Suitability Index (HSI) was developed by the USFWS as the basis of the Habitat Evaluation Procedure (HEP) and was discussed in Section 3.1 (this method is also discussed in Section 3.2.6). The HSI combines four measures of habitat value (food, cover, water quality, and reproduction) into one index that is an indicator of overall habitat quantity and quality. The basic procedure in conducting HEP is to first define the habitat and/or subhabitats present within the study area. For wetland systems this requires determination of the areal extent of different vegetation types and open water areas. The suitability of each subhabitat for supporting a selected group of ecologically or economically important species is determined by using the HSI. The index is developed from species-specific mathematical models that use physical and chemical data collected on the project site. The models define the habitat requirements of select species. To date, models for some 30 species of terrestrial and aquatic animals have been developed by the USFWS. The HSIs are used in combination with data on areal extent of each subhabitat to obtain the number of "Habitat Units" (HUs) that are available. The HUs reflect the overall quality and quantity of habitats on the project site or in the study area for individual species and/or groups of species. Impacts are determined by estimating changes in HUs over time --for example, alteration of the areal extent and biological populations as a result of construction.

Species diversity indices are generally used to analyze data on samples of populations or organisms. As previously mentioned, they usually combine information on equitability as well as species richness. Several types of indices are available that provide different measures of diversity. These include the Shannon-Wiener, Simpson, Brillouns index, and approximate and hierarchical indices (Kaesler et al. 1978; Krebs 1972). Also available are the Mason Index (Mason 1979) and the Sequential Index (Lind 1979). Since these indices are primarily concerned with submerged aquatic systems, they are not further addressed in this report. They could be used in detailed site-specific studies of individual wetland (pool) areas, but would not be useful as an initial screening tool.

Risk assessment indices measure the qualities of ecosystems to withstand stress (Cairns and Dickson 1980). These qualities include: (1) vulnerability to irreversible damage; (2) degree of elasticity or ability to recover from damage; (3) inertia or ability to resist displacement of structural and functional characteristics; and (4) resiliency (the number of times recovery can occur after displacement). Two types of risk assessment indices, the inertia index and the recovery index, have been developed. The recovery index provides a measure of ecosystem elasticity, and is a rough measure of the ability of a system to recover from damage (Cairns and Dickson 1980). Table 3.2-6 summarizes factors thought to determine the rate of recovery of an aquatic ecosystem from a perturbation, as well as the formula for calculating the recovery index (from Cairns and Dickson 1980).

The inertia index provides a numerical estimate of the ability of an ecosystem to resist displacement or perturbation. Critical factors used to rate an ecosystem's inertial ability and the formula for the inertial index are given in Table 3.2-7. A similar procedure is used to calculate the inertial and recovery indices. For further information concerning these indices the reader is referred to Cairns and Dickson (1980).

		RATING		
		1	2	3
(a)	Existence of nearby epicenters	Poor	Moderate	Good
(b)	Transportability of dissemules	Poor	Moderate	Good
(c)	Condition of habitat	Poor	Moderate	Good
(d)	Presence of residual toxicants	Large amounts	Intermediate amounts	Small amounts
(e)	Chemical-physical water quality	Severe disequilibrium	Partially restored	Normal
(f)	Regional management capabilities	None	Present	Strong

Recovery index = a x b x c x d x e x f

400-729: chances of rapid recovery excellent
55-399: chances of rapid recovery fair to good
<55: chances of rapid recovery poor

Note: Each factor can have a rating of 1, 2 or 3. The highest possible recovery index is 729 or 3^6, where each of the 6 factors have the highest rating of 3.

Table 3.2-6. Critical factors used in rating and determining recovery index (from Cairns and Dickson 1980).

		Rating		
		1	2	3
(a)	Tolerance of indigenous organisms to variable environment	Poor	Moderate	Good
(b)	High structural and functional system redundancy	Poor	Moderate	Good
(c)	Mixing capacity	Poor	Moderate	Good
(d)	Hard, well-buffered water	Poor	Moderate	Good
(e)	Closeness to ecological threshold	Close	Moderate margin of safety	Substantial margin of safety
(f)	Regional management capabilities	Poor	Moderate	Good

Inertial index = a x b x c x d x e x f

400-729: inertial stability high
55-399: inertial stability fair to good
>55: inertial stability poor

Note: Each factor can have a rating of 1, 2 or 3. The highest possible inertial index is 729 or 3^6, where each of the 6 factors have the highest rating of 3.

Table 3.2-7. Critical factors used in determining the inertial index (from Cairns and Dickson 1980).

3.2.6 Habitat Assessment Methods

A variety of habitat assessment methods have been developed that can or have been applied to wetlands (Lonard *et al*. 1981). This section discusses two methods developed by the U.S. Army Corps of Engineers (Reppert *et al*. 1979; USCOE 1980), the USFWS Habitat Evaluation Procedure (HEP) (briefly mentioned above), and the Michigan DNR wetland checklist procedure.

The advantages of such habitat-based methods are that they provide a standard and comprehensive means of scientifically evaluating wetland values. They are particularly useful where detailed site-specific information is needed (The MDNR method does not require the extent of data that the USFWS and USCOE methods require). The disadvantages (except for the Michigan DNR method) are that these methods require collection of a significant amount of on-site data by a team of biologists. The level of effort can vary greatly, but nevertheless, these methods would probably not be employed unless adverse effects on a wetland of very high value were projected.

3.2.6.1 Corps of Engineers Wetland Evaluation Methodology

The U.S. Army Corps of Engineers (Rempert *et al*. 1979) has developed a methodology for evaluating wetlands that involves two approaches: deductive and comparative analysis. This method was summarized in tabular form in Section 3.1. This section briefly summarizes the method.

In the deductive portion of the analysis, a systematic, qualitative method is used to evaluate functional wetland values. A narrative summary is prepared that describes how the wetland conforms or does not conform to the evaluation criteria. In the comparative analysis the degree to which two or more wetlands satisfy criteria regarding functional ecological characteristics and cultural features is evaluated. This is a quantitative procedure that allows comparison of several alternative sites. A final number is obtained that represents the total of individually evaluated features. This number is used as the basis for the comparative rating.

Both approaches rely on descriptive functional or cultural characteristics. Functional characteristics include those that define the value of a wetland for purification of surface water, groundwater recharge, or shoreline protection.

Cultural values would include aesthetics, agricultural use, recreational use, or commercial fisheries production. The deductive method assigns such values using a qualitative checklist, whereas the comparative method uses habitat mapping and a scaled checklist. Table 3.2-8 is an example of one scaled checklist used to evaluate the water purification function of a wetland. In this example, eight different factors are evaluated according to the criteria listed as having high (3), moderate (2), or low (1) value. These values are summarized to obtain a total which is indicative of the relative water purification function.

3.3.6.2 Corps of Engineers Habitat Evaluation System (HES)

The Habitat Evaluation System (HES) was developed by the U.S. Army Corps of Engineers for use in water resource project permitting (USCOE 1980). HES is a method for evaluating existing and future habitat conditions with and without a proposed project, and is based on a series of curves that define key habitat characteristics of aquatic species inhabiting the project area. The curves relate an index (called the Habitat Quality Index, or HQI) to various parameters or characteristics that reflect the quality of the study area with respect to supporting aquatic or terrestrial life. For aquatic systems, six curves relating HQIs to various parameters have been developed. These are: (1) fish species associations; (2) stream sinuosity; (3) total dissolved solids; (4) turbidity; (5) chemical type; and (6) benthic diversity. The curves for some of these parameters are presented in Appendix F.

The general steps in applying an aquatic HES to a project are as follows:

Evaluative Factors	Criteria	Value
A. Wetland Type		
1. Hydroperiod	● Semi-diurnal intertidal	High (3)
	● Perennial riverine	High (3)
	● Irregularly-flooded intertidal	Moderate (2)
	● Permanently-flooded lacustrine	Moderate (2)
	● Intermittently-flooded riverine	Low (1)
	● Intermittently-flooded lacustrine or palustrine	Low (1)
2. Vegetation density	● Dense (coverage > 80%)	High (3)
	● Moderate (coverage 50-80%)	Moderate (2)
	● Open (coverage 20-50%)	Low (1)
B. Areal and Waste Loading Relationships		
1. Total wetland size	● > 100 ac	High(3)
	● 10-100 ac	Moderate (2)
	● 1-10 ac	Low (1)
2. Proportion of water surface area in wetland area (acres, hectares)	● 40-60%	High (3)
	● 60-75%	Moderate (2)
	● > 75%	Low (1)
3. Proportion of tidal inlet, river channel or bay water volume flowing through wetland, or overland runoff retained in the system (cfs, mgd)	● > 50%	High (3)
	● 25-50%	Moderate (2)
	● < 25%	Low (1)
4. 5-day BOD loading (lbs BOD/acre/day)	● 5-15 lbs	High (3)
	● 15-25 lbs	Moderate (2)
	● > 25 lbs	Low (1)
C. Geographical and Other Locational Factors		
1. Frost-free days	● > 250 days	High (3)
	● 175-250 days	Moderate (2)
	● < 175 days	Low (1)
2. Location with reference to known pollution sources	● Below known source of municipal waste discharge	High (3)
	● Above known water intakes	High (3)
	● Below area of non-point-source pollution	Moderate (2)
	● Below known industrial waste discharges	Low (1)

Table 3.2-8. Criteria for scaling eight factors reflecting wetland values for water purification (Reppert et al. 1979).

- Obtain habitat type acreages;
- Derive HQI scores;
- Derive Habitat Unit Values (HUVs);
- Project HUVs for future with and without proposed project;
- Use HUVs to assess impacts of project alternatives; and
- Determine mitigation measures.

Figure 3.2-19 illustrates the various detailed steps required to complete a HES. Under the Habitat Evaluation System (HES), the quality of aquatic and terrestrial habitats are defined on the basis of established relationships between the habitat variables listed above and the Habitat Quality Index (HQI). HQIs are multiplied by available habitat type acreages to yield Habitat Unit Values (HUVs). The HUVs are the overall indicator of both habitat quality and quantity. Under HES, changes in HUVs produced by changes in habitat acreage or type may be used to determine impacts of various project alternatives.

Site-specific data are required to determine HQIs for baseline conditions under the HES. Future HQIs and HUVs are determined by combining information on project design (for example, changes in acreage resulting from land use changes, etc.) with data concerning projected changes in key habitat variables (for instance, turbidity). Data on changes in key project variables may be obtained in a variety of ways ranging from on-site measurements, modeling, or literature reviews. Therefore, a range of effort may be involved to complete an HES procedure that is dependent on the size of the project and degree of quantification desired.

A potential concern with HES is the scientific credibility of the results. While many of the HES calculations are based on assumptions similar to those used in HEP, accurate development of regionalized curves and the use of weighting factors will ultimately determine the credibility of this method. Presumably these factors could be computerized, but their reasonableness must still be considered by expert biologists before putting them to use.

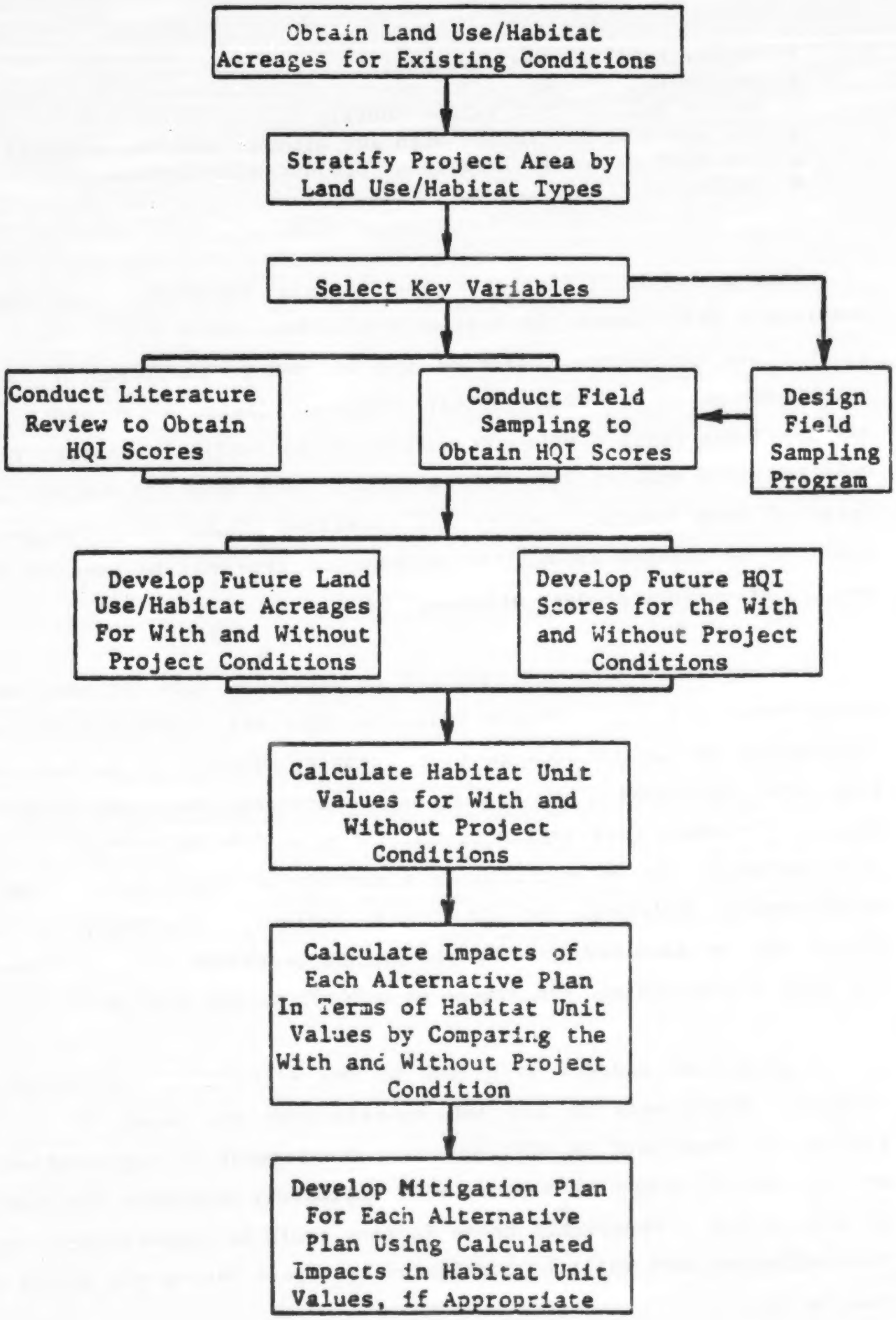

Obtain Land Use/Habitat Acreages for Existing Conditions
Stratify Project Area by Land Use/Habitat Types
Select Key Variables
Conduct Literature Review to Obtain HQI Scores
Conduct Field Sampling to Obtain HQI Scores
Design Field Sampling Program
Develop Future Land Use/Habitat Acreages For With and Without Project Conditions
Develop Future HQI Scores for the With and Without Project Conditions
Calculate Habitat Unit Values for With and Without Project Conditions
Calculate Impacts of Each Alternative Plan In Terms of Habitat Unit Values by Comparing the With and Without Project Condition
Develop Mitigation Plan For Each Alternative Plan Using Calculated Impacts in Habitat Unit Values, if Appropriate

Figure 3.2-19. Detailed steps in preparing a "HES" (from USCOE 1980)

3.2.6.3 U.S. Fish and Wildlife Service Habitat Evaluation Procedure

The Habitat Evaluation Procedure (HEP) (USFWS 1980) is a method that utilizes physical, chemical, and biological information to characterize the biological carrying capacity of terrestrial and aquatic systems. HEP provides a means of evaluating baseline habitat conditions and the ecological impacts of various project alternatives. The application of HEP is relatively straight-forward but requires evaluation of the site by a team of at least three biologists trained in the procedure. The overall procedure is similar to HES, except that the two methods are based on somewhat different assumptions.

The basic procedure in conducting an HEP is to first define the habitat and/or subhabitats present within the study area (Figure 3.2-20). For wetland systems this requires determination of the areal extent of pools and vegetation types. The suitability of each sub-habitat for supporting a selected group of ecologically or economically important species is determined by using what is termed a "Habitat Suitability Index (HSI)." The index is developed from mathematical models that use physical and chemical data collected on the project site to define carrying capacity of individual species. To date, models for some 30 species of terrestrial and aquatic animals have been developed by the USFWS. The information generated concerning carrying capacity is used to define the overall quantity and quality of habitat in a given area.

The HSIs are used in combination with data on areal extent of each subhabitat to obtain the number of "Habitat Units" (HUs) that are available. The HUs reflect the overall quality and quantity of habitats on the project site or in the study area for individual species and/or groups of species. Impacts are determined by estimating changes in HUs over time --for example, alteration of the physical habitat as a result of construction (Figure 3.2-20). For wetland projects this would involve projecting the changes in acreage of individual habitat types caused by a proposed project. The numbers of acres of habitat are calculated for each of several target years, and the resulting HUs are then computed. A graph of available HUs with and without the project may be constructed to visually

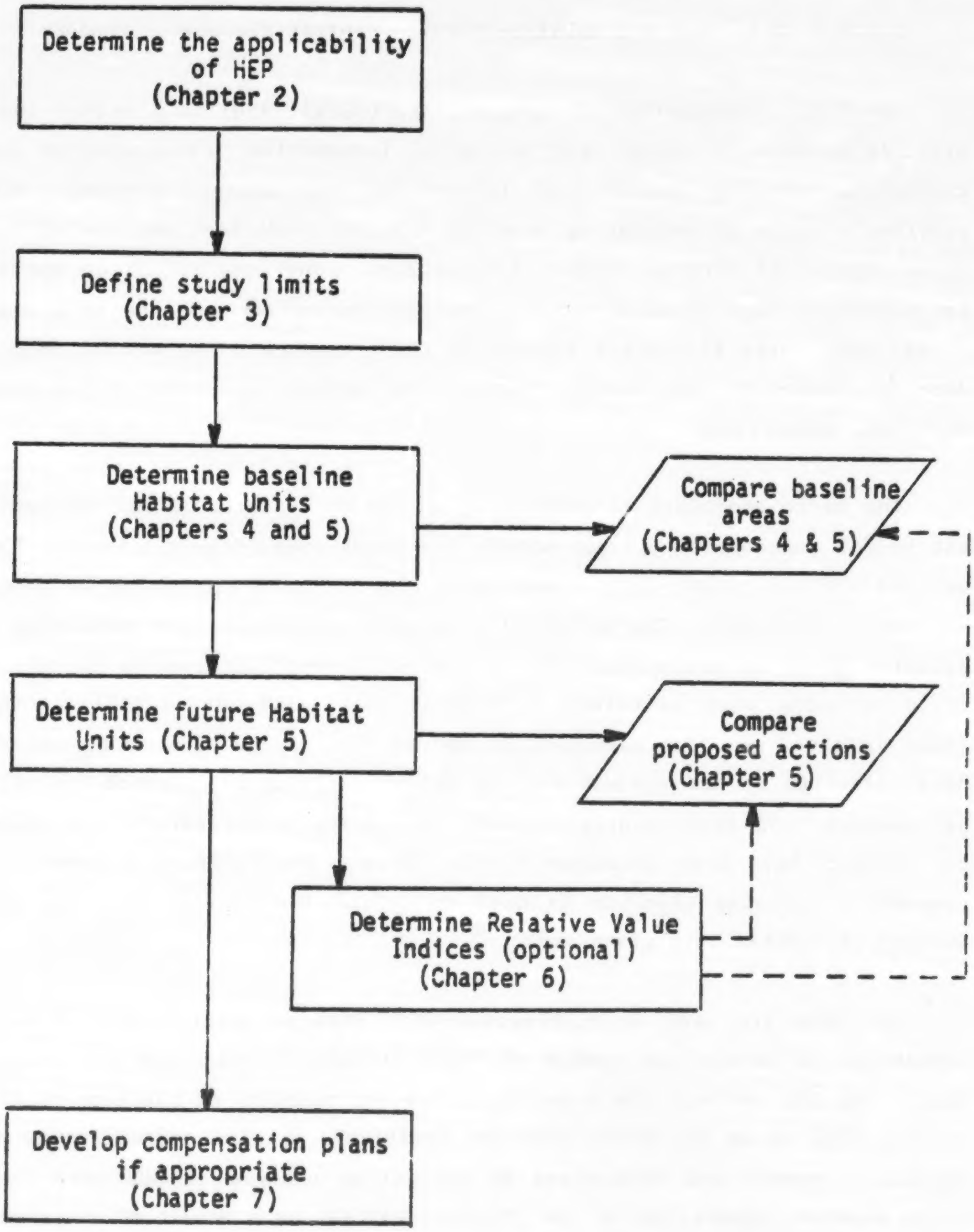

Determine the applicability of HEP (Chapter 2)
Define study limits (Chapter 3)
Determine baseline Habitat Units (Chapters 4 and 5)
Compare baseline areas (Chapters 4 & 5)
Determine future Habitat Units (Chapter 5)
Compare proposed actions (Chapter 5)
Determine Relative Value Indices (optional) (Chapter 6)
Develop compensation plans if appropriate (Chapter 7)

Figure 3.2-20. Generalized evaluation procedure for employing HEP (from USFWS 1980b)(Chapters indicated refer to the USFWS HEP manual, not the present study).

illustrate the effects of the proposed activity over time (Figure 3.2-21). HEP also provides a means of developing trade-offs and compensations using similar projections (these are not discussed further here).

The primary disadvantage of using the HEP is that large amounts of site-specific data may be required if impact quantification is desired. These data must be obtained by a team of at least three biologists trained in HEP. For the semi-quantitative method in which the full-scale models are not employed, the need for extensive data is not a problem. However, a full-scale HEP requires a substantial investment of labor and funds.

The main advantage of using HEP is that a number of numerical models are available and are continually being developed by the USFWS so that the method can be applied in any region where the evaluation species occurs. In addition, computer programs for both the models and the impact analysis are currently available for large main-frame computers. The USFWS is also currently developing HEP software for use on microcomputers so that the technique can be used by other organizations (Bruce Bell, USFWS HEP coordinator, Atlanta, Georgia, personal communication). An additional advantage of using HEP is that a range of HSI models are available that allow for a varied level of effort to complete an analysis for a particular project. HEP is also advantageous because it provides a quantitative or semi-quantitative means of analyzing the potential impacts of a project. This provides a common ground for discussion between reviewing agencies or between biologists, hydrologists, and engineers working on a project. The USFWS is actively funding the HEP system and in the future plans to use it as the primary means of assessing baseline conditions and impacts. This is an additional reason favoring its incorporation by other agencies, since it would provide a common means of conducting impact analysis and for agencies to discuss specific aspects of permit decisions (especially mitigation).

HEP also provides a means of analyzing trade-offs of project alternatives, as well as a means of conducting compensation analyses. These methods are given in USFWS's manual ESM 102 and are not discussed further here. However, these methods are extremely valuable when setting permit conditions or in considering consequences of project alternatives and means to minimize impacts (especially for large projects).

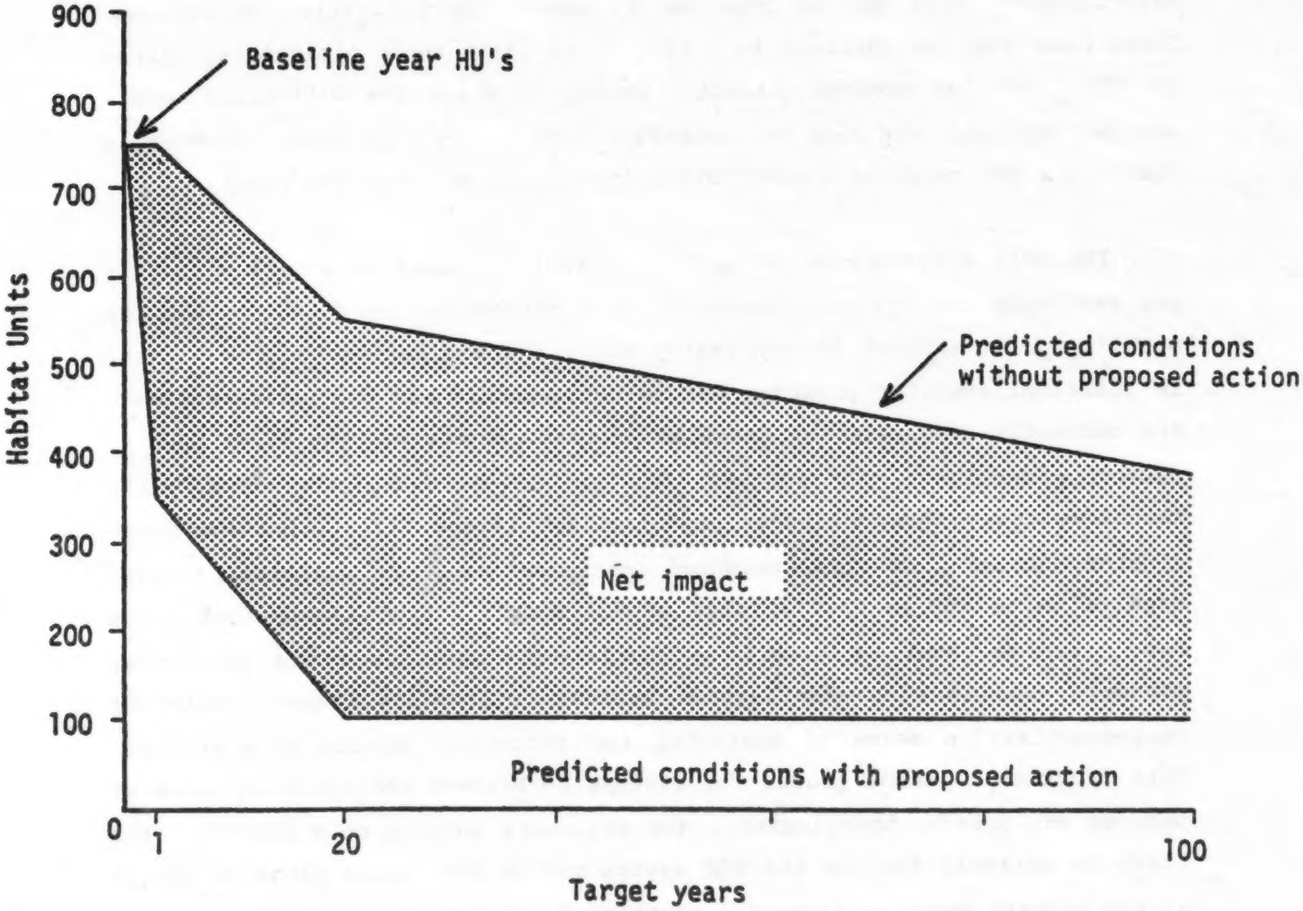


Figure 3.2-21. Relationship between baseline conditions, conditions without a proposed action, conditions with a proposed action and net impact (from USFWS 1980b).

3.2.6.4 Michigan DNR Wetland Evaluation Checklist Technique

The MDNR checklist method provides a means of evaluating the status of existing wetlands as well as potential project-related impacts on wetland structure and areal extent. The method is specific to wetlands and is not strictly applicable to aquatic systems (with the possible exception of the fisheries portion). The method examines six basic features of wetlands, including: (1) hydrologic functions (classification, flood reduction value, drainage changes); (2) soil characterizations (texture, coloration, mottling, water table, hydric soils, organic/mineral soils); (3) wildlife habitat/use evaluation (utilization, interspersion, vegetative cover); (4) fisheries habitat/ use (utilization, vegetation type); (5) nutrient removal/recycling functions (storage/release); and (6) removal of suspended sediments. A portion of this checklist is shown in Figure 3.2-22. A second part of the analysis includes consideration of public interest concerns. This method also includes brief consideration of cumulative, cultural/historic and economic impacts.

To conduct the first portion of the analysis, a checklist procedure is followed for each of the six functional areas to be evaluated. A numerical rating system is used to rank the quality of the site with respect to each ecological function. For wildlife and fisheries, a rating system is used in which a composite score is determined for several groups of species and their respective ecological uses of the wetland. The rating system is used to evaluate the wetland before and after construction. A one-day site visit is required to conduct this evaluation.

The advantages of using this method are that it: (1) requires a low level of effort; (2) provides a ready means of quantifying baseline conditions, which enables a more objective impact analysis; and (3) includes consideration of non-ecological impacts such as effects on cultural and economic resources. A disadvantage is that the method may not be quite detailed enough to provide the type of data needed for a more scientific evaluation. However, as a quick screening method, it should be given close consideration for future use (possibly by slight expansion or modification it could be useful in 201-type project reviews as a screening tool).

PART I. Cont'd.

II. SOIL DESCRIPTION

1. If a modern soil survey is available, list the soil types of the wetlands:

____

____

2. Soil Inspection — Dig a 24" deep hole and determine:
   A. Depth to water table: _______ inches (NR = Not Reached)
   B. If site is inundated, average water depth: _______ inches.
   C. Depth to start of mottling: _______ inches (NR = Not Reached)

3. Soil Classification — Classify the soil (either A or B)
   A. ☐ ORGANIC (greater than 20% organic matter and deeper the 12".)
      1. ☐ MUCK (highly decomposed, original plant parts not recognizable.)
      2. ☐ PEAT (largely undecomposed, plant parts readily recognizable.)
   B. ☐ MINERAL (less than 20% organic matter or if greater than 20%, shallower than 12").
      1. Describe the soil horizons, from the surface down.

DEPTH	TEXTURE¹	COLOR²
0 to "		
" to "		
" to "		

TEXTURE¹

S — sand
SL — sandy loam
LS — loamy sand
L — loam
SIL — silt loam
CL — clay loam
C — clay
RC — rock/cobbles
CS — cobbly sand
note other

COLOR²

R — red
BR — brown
B — black
Y — yellow
G — gray
RB — reddish brown
GB — grayish brown
RY — reddish yellow
note other

III. WILDLIFE USE/HABITAT EVALUATION

A. Wildlife Use Rating: (complete the table below)

	Nesting/ Rearing Young		Feeding		Cover		Sub-Total		Comments
	Before	After	Before	After	Before	After	Before	After	
Waterfowl		▨		▨		▨		▨	
Other game birds		▨		▨		▨		▨	
Wading birds		▨		▨		▨		▨	
Shorebirds, Gulls, Terns		▨		▨		▨		▨	
Non-game birds		▨		▨		▨		▨	
Raptors		▨		▨		▨		▨	
Furbearers		▨		▨		▨		▨	
Other mammals		▨		▨		▨		▨	
						TOTALS		▨	

Wildlife use rating **BEFORE** project = $\frac{\text{TOTAL}}{24} = \frac{\_\_\_\_}{24} = \boxed{}$

Wildlife use rating **AFTER** project = $\frac{\text{TOTAL}}{24} = \frac{\_\_\_\_}{24} = \boxed{}$

B. VEGETATIVE INTERSPERSION RATING = ☐

C. VEGETATIVE COVER TO OPEN WATER RATING = ☐

D. COMMENTS: ______________________________

____

____

Biologist's Signature (if applicable) ______________________ **Date** ____ / ____ / ____

Figure 3.2-22. Portion of MDNR wetland evaluation checklist (MDNR 1980).

3.2.7 Ecosystem Modeling

The USFWS study summarized information on available methods for modeling aquatic ecosystems (including wetlands) (Table 3.2-9). Modeling could be employed as a means of analyzing primary, secondary or cumulative effects of 201 projects on wetlands. Two general types of modeling, physical and mathematical, are available. Most of the methods listed in Table 3.2-9 apply to aquatic ecosystems. However, the methods for modeling habitat creation listed in Table 3.2-9 would apply directly to wetlands mitigation techniques. Modeling is considered to be an expensive and labor-intensive means of evaluating baseline conditions and potential effects of project activities on wetlands. As such, it would be impractical as a rapid screening method for use in USEPA Region V projects.

3.3 Other Methodologies

Sections 3.1 and 3.2 provided reviews of the majority of the methodologies that have been developed to assess impacts of various activities on wetlands in USEPA Region V and elsewhere. Most of the literature reviewed dealt with primary impacts assessment methods developed prior to 1981. This section reviews other types of methods that have been developed subsequent to 1981 or that deal with other types of impacts on wetlands that need to be considered during the course of facilities planning. In particular, cumulative impacts, secondary impacts, and mitigation are important aspects of the review process that need to be addressed.

3.3.1 Federal Highway Administration Study

The Federal Highway Administration (FHWA) has published a two-volume series of a wetland evaluation procedure (Adamus and Stockwell 1983; Adamus 1983). Volume I presents a state-of-the-art review of wetland functions. These include groundwater recharge and discharge, flood storage and desynchronization, shoreline anchoring and dissipation of erosive forces, sediment trapping, nutrient retention and removal, food chain support (detrital export), habitat for fish and wildlife, and active and passive recreation. The manual is applicable to all wetlands in the 48 conter-

Ecological Problem Areas	Applicable Modeling Approaches						
	Physical			Mathematical			
	B	M	SE	DO	CHEM	PHYTO	ECO
Land and Confined Disposal							
Colonization and ecological succession	--	*	--	--	--	--	**
Biological productivity	--	*	*	--	--	--	--
Species diversity	--	--	--	--	--	--	--
Material cycling+	--	*	*	--	--	--	**
Return flows and receiving water impacts	--	*	*	*	--	**	**
Habitat Creation							
Colonization and ecological succession	--	*	--	--	--	--	**
Biological productivity	--	*	*	--	--	--	**
Species diversity	--	--	--	--	--	--	--
Material cycling+	--	*	*	--	--	--	**
Artificial establishment techniques	--	*	*	--	--	--	--
Open-Water Disposal							
Pelagic							
• Oxygen budget analysis	--	--	--	*	--	--	**
• Biological productivity	--	*	*	--	--	**	**
• Species diversity	--	--	--	--	--	--	--
• Material cycling+	--	*	*	--	--	--	**
Benthic							
• Direct smothering of benthic organisms	--	*	--	--	--	--	--
• Colonization and ecological succession	--	*	--	--	--	--	**
• Biological productivity	--	*	*	--	--	--	**
• Species diversity	--	--	--	--	--	--	--
• Material cycling+	--	*	*	--	--	--	**
Pollution Criteria Development	*	*	--	*	**	**	**

Notes: B = bioassays; M = microcosms; SE = scaled ecosystem; DO = dissolved oxygen; CHEM = chemical; PHYTO = phytoplankton; ECO = ecosystem.

*State of the art ready for application with only minor adaptations.
**State of the art not ready for application but development for selected purposes is feasible.
+Includes contaminant mobilization and transport.

Table 3.2-9. Ecological problems related to dredged material disposal and features of applicable modeling methods (from Hall et al. 1976).

minous states, and uses the U.S. Fish and Wildlife Service definition and classification system. It examines the validity, interactions, and possible significance thresholds for the functions, as well as documenting their underlying processes. With appropriate qualifying information, wetland types are ranked for each function. Wetland types ideal for each function are identified and illustrated. Potential impacts of highways upon each function are described and, where available, possible thresholds are given. Factors that regulate impact magnitude, such as location, design, watershed erodibility, flushing capacity, basin morphology, biotic sensitivity (resistance and resilience), recovery capacity, and wildlife refugia, are explained. Cumulative impacts and social factors affecting wetland significance are discussed. Effects of the following factors on wetland function are documented: contiguity, shape, fetch, surface area, area of watershed and drainage area, stream order, gradient, land cover, soils, depositional environment, climate, wetland system, vegetation form, substrate, salinity, pH, hydroperiod, water level fluctuations, tidal range, scouring, velocity, depth, width, circulation, pool-riffle ratio, vegetation density, flow pattern, interspersion, human disturbance, turbidity, alkalinity, dissolved oxygen, temperature, and biotic diversity. Because of the great length of Volume I, it will not be further discussed here. Volume II presents a methodology for screening each of the functional values of wetlands as described in Volume I.

The methodology is in fact three separate procedures, including the following:

- Procedure I (Threshold Analysis) estimates the relative likelihood that a single wetland is of high, moderate, or low value for each function;
- Procedure II (Comparative Analysis) provides a framework for estimating whether one wetland is likely to be more important than another for each function; and
- Procedure III (Mitigation Analysis) provides a framework for comparing mitigation alternatives and evaluating their "reasonableness."

The threshold analysis must be completed first. The last two procedures are employed only if Procedure I does not allow adequate determination of functional value. The method is based on the assumption that a wetlands value includes three components. These are: (1) "opportunity" (whether a wetland has a chance to fulfill a given function); (2) "effectiveness" (probability that a wetland is productive in maximizing the opportunity of fulfilling a given function); and (3) "significance" (the degree to which the function performance is valued by society). Figure 3.3-1 summarizes the interaction of these three characteristics.

To complete Procedures I and II, the evaluation goes through two basic steps. In Step 1, the evaluation uses three series of questions called "predictor inventories". The first series is used to evaluate opportunity and effectiveness, the second series determines significance, and the third series reviews impact related factors. In the second step, the information assembled in the three predictor inventories is evaluated to determine a rating of functional significance for each function. In Procedure I, "interpretation keys" are provided to help translate the data into statements concerning functional significance. A detailed diagram of the methodology is shown in Figure 3.3-2. Example sheets of forms A, B, and C, as well as all subsequent forms included in the method, are included in Appendix G in order to illustrate the substantial amount of effort required by this technique. In general, the procedure can be used for: (1) determining sensitivity of alternate corridors; (2) assigning mitigation measures that are consistent with wetland values; (3) choosing replacement wetlands of equal functional value if replacement is desired; and (4) allocating the appropriate level of effort to any further detailed studies, if required.

The output of the methodology is used to screen wetland functions and is not intended to be used for detailed site studies. Rather, the method should be used to choose from a large array of choices and possible priorities for later, detailed studies. The analyses result in a rating of high, moderate, or low with respect to the significance of analysis of a

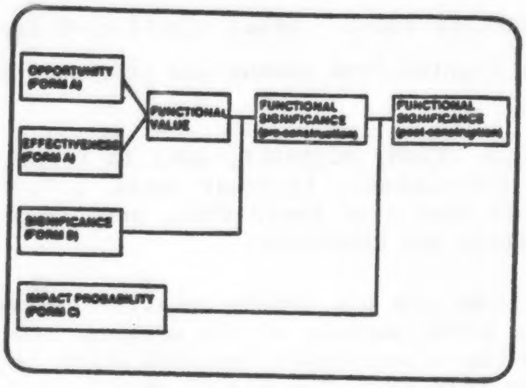
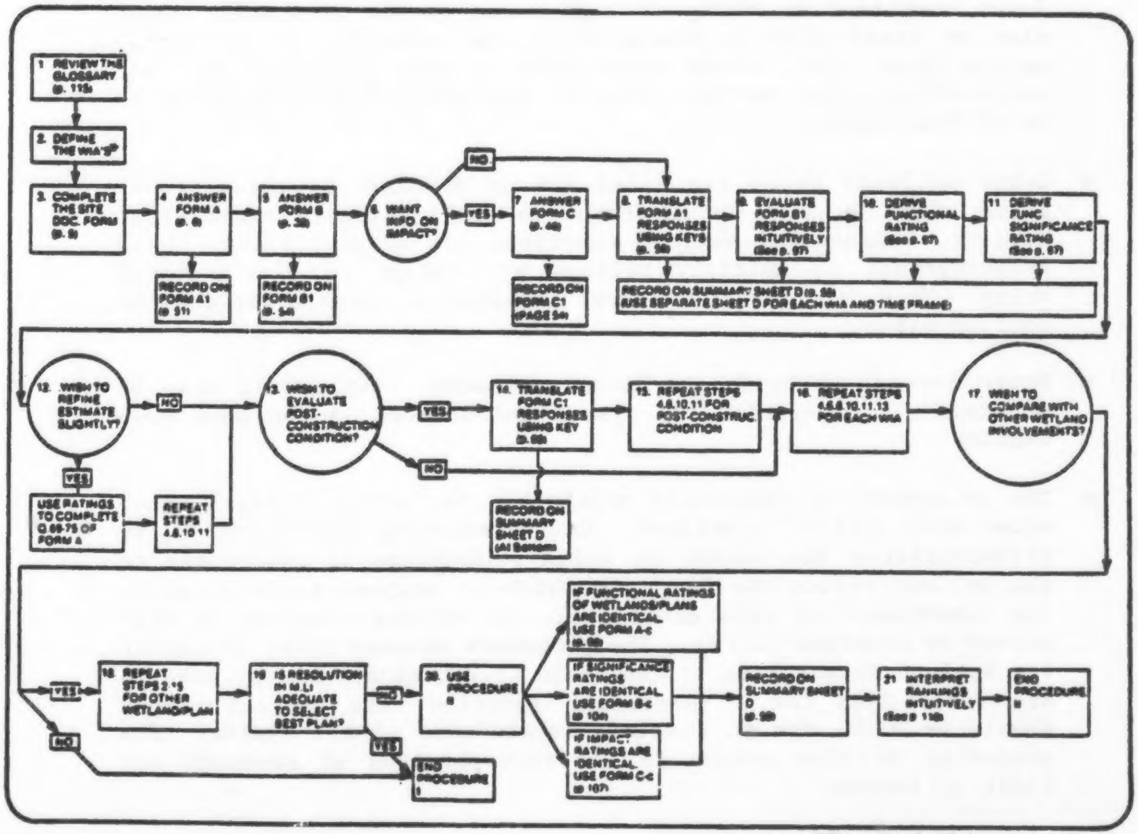

OPPORTUNITY (FORM A)
EFFECTIVENESS (FORM A)
SIGNIFICANCE (FORM B)
IMPACT PROBABILITY (FORM C)
FUNCTIONAL VALUE
FUNCTIONAL SIGNIFICANCE (pre-construction)
FUNCTIONAL SIGNIFICANCE (post-construction)

Figure 3.3-1. The relationships between the concepts of opportunity, effectiveness, and significance in evaluation of wetland values and functions (from Adamus 1983).


1 REVIEW THE GLOSSARY (p. 113)
2. DEFINE THE WIA'S*
3. COMPLETE THE SITE DOC. FORM (p. 9)
4 ANSWER FORM A (p. 9)
5 ANSWER FORM B (p. 32)
6. WANT INFO ON IMPACT?
NO
YES
7 ANSWER FORM C (p. 40)
8. TRANSLATE FORM A1 RESPONSES USING KEYS (p. 58)
9. EVALUATE FORM B1 RESPONSES INTUITIVELY (See p. 97)
10. DERIVE FUNCTIONAL RATING (See p. 97)
11 DERIVE FUNC SIGNIFICANCE RATING (See p. 97)
RECORD ON FORM A1 (p. 31)
RECORD ON FORM B1 (p. 34)
RECORD ON FORM C1 (PAGE 54)
RECORD ON SUMMARY SHEET D (p. 98) (USE SEPARATE SHEET D FOR EACH WIA AND TIME FRAME)
12. WISH TO REFINE ESTIMATE SLIGHTLY?
NO
YES
USE RATINGS TO COMPLETE Q.69-75 OF FORM A
REPEAT STEPS 4,8,10,11
13. WISH TO EVALUATE POST-CONSTRUCTION CONDITION?
YES
NO
14. TRANSLATE FORM C1 RESPONSES USING KEY (p. 88)
RECORD ON SUMMARY SHEET D (At Bottom)
15. REPEAT STEPS 4,8,10,11 FOR POST-CONSTRUC. CONDITION
16. REPEAT STEPS 4,5,8,10,11,13 FOR EACH WIA
17. WISH TO COMPARE WITH OTHER WETLAND INVOLVEMENTS?
YES
NO
18. REPEAT STEPS 2-15 FOR OTHER WETLAND/PLAN
19 IS RESOLUTION (H M L) ADEQUATE TO SELECT BEST PLAN?
NO
YES
END PROCEDURE I
20. USE PROCEDURE II
IF FUNCTIONAL RATINGS OF WETLANDS/PLANS ARE IDENTICAL, USE FORM A-c (p. 99)
IF SIGNIFICANCE RATINGS ARE IDENTICAL, USE FORM B-c (p 104)
IF IMPACT RATINGS ARE IDENTICAL, USE FORM C-c (p 107)
RECORD ON SUMMARY SHEET D (p. 98)
21 INTERPRET RANKINGS INTUITIVELY (See p 110)
END PROCEDURE II

*WIA = wetland impact area

Figure 3.3-2. Flow chart of the method developed by Adamus (1983) to evaluate baseline conditions in wetlands and effects of highway construction.

function, and potential impacts. However, the method only assures the probability that such functions exist. Other significant features of this method that are as follows (quoted from Adamus and Stockwell 1981):

- The probability ratings (HIGH, MODERATE, LOW) in Procedure I do not have statistical correlates. In other words, a "LOW" rating has not been proven to mean that fewer than, say, 10 percent of all wetlands will satisfy the condition;

- Nevertheless, the ratings are not merely relative. Depending on the function, perhaps 60-80 percent of the wetlands described in the literature as having a particular function might be assigned a rating of "HIGH" by this key. The key is usually quite rigorous in its stipulations for arriving at a HIGH or LOW rating for a function; the user may find that a large number of evaluations result in ratings of MODERATE;

- Procedures I and II are constructs of the available technical literature and hence are only, at best, as good as the literature base, which in many areas is deficient. Thus, while most wetlands described as being of high value in the literature would also be rated HIGH by Procedure I, the converse is not necessarily true, i.e., areas rated HIGH by this procedure will not necessarily, upon further detailed analysis, always be found to be of high value;

- Large wetlands which are rated LOW or MODERATE by these procedures might be just as important as small wetlants rated HIGH. However, because few wetland functions can be quantified, it is inappropriate to multiply ratings by acreage to give a total value. Thus, it is best whenever possible to compare wetlands of similar size;

- Where several wetlands are being evaluated, they should also be of similar hydro-period and system and located in the same ecoregion;

- The procedure is especially applicable to "strip takings" which alter only part of a wetland. Unlike existing methodologies, it differentiates the extent to which a function is ascribable to the wetland versus the basin in which it happens to be located. The importance of this distinction to wetland function is discussed by Cowardin (1979). The procedure assumes that, if either the wetland impact area or the basin (i.e., adjacent deep waters) are rated HIGH for a particular function, the overall rating should be HIGH, due to the interrelatedness of the system. The procedure is also unique in its incorporation of seasonal and tidal variation;

- The procedure does not provide for a synthesis of individual functional values into an overall wetland value, because the weights of individual functions (e.g., whether the user should be more concerned with the wetland's value for nutrient retention or for wildlife habitat, both of MODERATE probability) varies according to the user's priorities. If an overall value must be assigned, perhaps the best guideline is for this to be synonymous with the wetland's highest functional significance rating; and

- The development of this procedure should be viewed as an ongoing process. Although it is perhaps the most accurate procedure of its type available at this time, future revisions may be made. Users are encouraged to forward their suggestions the Federal Highway Administration as well as the authors.

Despite the fact that the FHWA method is portrayed as a "rapid screening" technique, a substantial amount of effort (several days) is required to complete an evaluation. This factor should be considered in the future by USEPA if it desires to employ the FHWA method.

3.3.2 Wisconsin DNR Method

The Wisconsin Department of Natural Resources (USCOE 1983) has prepared a wetland evaluation methodology in cooperation with the U.S. Army Corps of Engineers, Rock Island Illinois District. The method is to be used as a screening technique in projects involving wetlands that are reviewed by the state during permitting and facilities planning. The WDNR methodology is in fact a modification of the FHWA method (Adamus and Stockwell 1983, Adamus 1983) presented in Section 3.3.1 of this report. Although the WDNR method is very similar in general format to the FHWA method, it is tailored specifically to biological characteristics of Wisconsin wetlands (i.e., the method includes plants and animals that occur specifically in Wisconsin and focuses specifically on Wisconsin wetland community types) (W. Marlett, WDNR, personnel communication). In addition, the WDNR method is shorter than the FHWA method, and requires a lower level of effort to complete (the FHWA method requires several days of effort).

3.3.3 Ludwig and Apfelbaum Matrix Method

Ludwig and Apfelbaum (unpublished) created a matrix method to evaluate the functional aspects of wetlands. The method is based on the assumption that functional wetland values can be measured (quantified and used as the basis to evaluate baseline conditions). The ultimate objective of the authors is to have resource managers use the method in everyday planning and administration. The specific objectives of the study are as follows:

- To be able to measure and value the functions of wetlands on a case-by-case basis;
- To develop a list of standard parameters which when measured provide an index of wetland value;
- To develop a system that is usable by anyone able to use standard methods of measurement and procedures;
- To devise a wetlands assessment system in which a numerical index is generated as a measure of baseline value, and by which a researcher is able to compare wetlands to each other, and to predict the impacts of proposed uses or modification both in the short-term (50 years) and the long-term (50 years);
- To place the burden of proof on any person, agency, or organization that seeks to use, modify, or manage any wetland for any purpose to prove that it is in the public--as well as the private--interest to use the wetland as proposed; and
- To stimulate the scientific community to consider proper weighting, methodologies for valuing, and measurement of each parameter.

A set of 24 parameters associated with wetlands which can be measured and which define wetlands functional values were developed (Table 3.3-1). These are divided into four main sub-divisions: biological, hydrological and human use, and resistance to disturbance (Table 3.3-1 and Appendix H).

In this method, a maximum and minimum numerical value is assigned to each of the 24 parameters, and these are then summed to provide an aggregate score for each of the three major subdivisions. Specific quantitative methods for determining individual scores and score sheets are provided in Appendix H.

The method is applied by use of a matrix (Table 3.3-2). In the first column, baseline values from each of the four major categories are presented. Subsequent columns include projections of values over the next 50 years with and without the proposed project. Columns for presenting values

Table 3.3-1. Key parameters for defining wetland functional values

I. BIOLOGICAL PARAMETERS

A. Plant Diversity (Species Richness)
B. Plant Productivity (Measured as Annual Rate of Primary Production)
C. Plant Communities
D. Animal Diversity (Species Richness)
E. Animal Productivity (Actual Carrying Capacity as a Nesting-Brooding-Rearing Habitat)
F. Migratory Species Habitat (Value as Temporary Habitat)
G. Presence of Rare, Threatened and Endangered Species
H. Critical Habitat(s) Rating (Local, Regional, Statewide)
I. Ecosystem Wholeness Rating

II. HYDROLOGICAL PARAMETERS

A. Physical and Configurational Attributes
  1. Flood Control/Amelioration Function
  2. Sediment Trap Function
  3. Surface Water Storage Function
  4. Groundwater Recharge Function
  5. Biomass Sink and Storage Function
  6. Watershed Importance Rating
B. Physio-Chemical Attributes
  1. Water Quality, Bacteria, BOD/COD, Nutrients, pH, Heavy Metals, etc.
  2. Cation Exchange and Storage Capacities

III. HUMAN USE PARAMETERS

A. Aesthetic Values
B. Present Value of Wetland Products and Services
C. Potential Value of Competitive Human-Controlled Uses
D. Recreation Values
E. Rareness of the Wetland Resource, Local and Statewide
F. Management Potentials for Long-Term Maintenance in Present Form
G. Holistic Ecosystem Importance Rating

IV. OVERALL SYSTEM RESILIENCE TO DISTURBANCE

WETLANDS VALUING MATRIX

Perkowski Tract-St. John's Marsh
St. Clair County, MI

	Wetland Parameters	Maximum Values	Baseline Values	Value if Left to Existing Trends	Intrinsic Value Change	50 yrs. Value if Used As Proposed	Value Change As Proposed	Value if Mitigated to the Extent Possible	Value Change with Mitigation
		Wetland Values							
BIOLOGICAL	Plant Diversity	30	24	23	- 1	3	- 21	24	0
	Plant Productivity	20	21	20	- 1	14	- 7	18	- 3
	Plant Communities	20	15	15	0	1	- 11	14	- 1
	Animal Diversity	30	8	7	- 1	1	- 7	14	+ 6
	Animal Productivity	20	8	6	- 2	1	- 7	12	+ 4
	Migratory Species Habitat	15	25	21	- 4	2	- 23	20	- 5
	Rare, Threatened & Endangered Sp.	30	5	5	0	1	- 4	3	- 2
	Critical Habitat Rating	20	6	4	- 2	1	- 5	8	+ 2
	Ecosystem Wholeness	20	7	6	- 1	1	- 6	13	+ 6
HYDROLOGICAL	Food Control Function	20	2	2	0	1	- 1	1	- 1
	Sediment Trap Function	20	15	14	- 1	1	- 14	8	- 7
	Surface Water Storage Function	15	2	2	0	1	- 1	1	- 1
	Groundwater Recharge Function	20	1	1	0	1	0	1	0
	Biomass Storage Function	10	8	7	- 1	1	- 7	5	- 3
	Watershed Importance Rating	25	22	22	0	11	- 10	21	0
	Water Quality Functions	20	12	11	- 1	7	- 5	16	+ 4
	Cation Exchange & Storage	20	10	9	- 1	2	- 8	7	- 3
HUMAN USE	Aesthetic Values	30	26	24	- 2	8	- 18	18	- 8
	Present Economic Value	30	8	13	+ 5	30	+ 22	28	+20
	Potential Economic Value	30	12	16	+ 4	30	+ 18	30	+18
	Recreational Values	30	25	28	+ 3	30	+ 5	30	+ 5
	Resource Rareness	30	25	20	- 5	5	- 20	17	- 8
	Management Potential	-20-0	- 8	- 7	+ 1	- 7	+ 1	- 10	- 2
	Holistic Ecosystem Rating	27	19	16	- 3	+ 5	- 14	26	+ 7
	Ecosystem Resilience Rating	50	35	32	- 3	6	- 29	38	+ 3
	Sum of Values	582	333	317	-16	151	-172	364	+31
	Relative Score as % of maximum Score of 582 pts.	100%	57%	54%	- 3%	26%	31%	63%	+ 6%

Table 3.3-2. Wetland evaluation matrix devised by Ludwig and Apfelbaum.

with mitigation are also included. The method also includes a means of estimating the effects of changes in the surrounding watershed on the wetland, and a means of differentiating between a projected trends baseline (natural wetland changes without project) and baseline conditions (wetland values at time Y, regardless of natural successional or other changes).

The advantage of the system is that it provides an objective means to assess wetland values. This allows for more realistic and objective permit or planning decisions to be made. However, as can be seen by reviewing the tables in Appendix H, the method also requires detailed site-specific data-gathering on a variety of wetland features. Therefore, the method is not a screening method but rather is intended for use on a highly site-specific basis. This also implies that the cost and labor reqirements for this approach would be high. The matrix, however, could provide a useful means of summarizing "red flag" features.

3.3.4 US Office of Technology Assessment Study (Mitigation)

The Oceans and Environment Program, Office of Technology Assessment (US Congress) is currently preparing a study that includes a literature review of dredge and fill construction and development impacts on wetlands, feasibility of wetland creation and restoration, and means of mitigating impacts of human activity on wetlands (Nelson _et al_. 1982e). Because of the importance of the subject, this section reviews the portion of the OTA study dealing with measures to mitigate impacts on wetlands. The study includes the following four main aspects of mitigation: (1) examples of types of mitigation; (2) feasibility of mitigation; (3) strategies available for implementation of mitigation measures; and (4) Section 404-related mitigation measures. The following sections briefly summarize the first two of these four areas as presented in Nelson _et al_. (1982e) (the last two areas are not within the scope of this review).

3.3.4.1 Examples of Wetland Impact Mitigation

Mitigation may include a variety of the following measures: (1) avoiding wetland impacts altogether during planning or construction phases, or determining means to reduce impacts; or (2) compensation for unavoidable on-site impacts by creation of wetlands off-site. The OTA study considered types of mitigation that could be accomplished at each of several orders of magnitude of impact. A "first order of magnitude" impact would include total wetland elimination. Examples given include filling, bulkheading draining, and clearing. Table 3.3-3 summarizes various means to mitigate these types of impacts. Second order magnitude impacts which are defined as those which occur over longer periods of time. These could include for example, hydrological effects resulting from blocking of drainage due to highway construction or drainage of wetlands due to access canal dredging. Mitigation measures for these types of activities are listed in Table 3.3-4. Third-order magnitude 404-related impacts are defined in the OTA study as those resulting in long-term soil and substrata effects. Many of these are also relevant to facilities planning. An example of a third-order impact would include gradual filling of a wetland due to increased sedimentation from a surrounding disturbed area. Table 3.3-5 lists ways to mitigate such impacts. Fourth-order impacts were identified as those that result in water quality degradation over the long-term, and which result from effects of sewage effluents (eutrophication) or deterioration due to other activities (peat mining is used as an example in the OTA study). Table 3.3-6 lists measures to mitigate these types of impacts.

The highest order of magnitude of impact identified in the OTA study was the fifth order. This includes short-term physical/chemical effects of construction, such as increased turbidity during pipeline laying or direct habitat elimination. Examples of appropriate mitigative measures identified are shown in Table 3.3-7.

Table 3.3-3. Examples of onsite mitigation practices useful for filling and bulkheading (adapted from various sources in Nelson et al. 1982).

Activity	Mitigation Concept	Reference
Filling	• To achieve flushing of finger-fill canals, avoid dead ends, sharp elbows, and mean low depths over 4 to 6 feet	Hicks et al. 1975
	• Clean, unpolluted materials should be used for fill	Hubbard and Blair 1979
	• All material should be retained by dikes or bulkheads	Canter et al. 1977
	• The top and outside bank of the dikes should be vegetated	Canter et al. 1977
	• There should be a vegetative buffer strip at the outer limits of the fill to stabilize the soil surface	Canter et al. 1977
	• After filling, the new surface should be prepared with fertilizer, lime, mulch, or topsoil as needed for successful seeding	Canter et al. 1977
Bulkheading	• Should be considered only when riprap or vegetative shore protection is infeasible	Hubbard and Blair 1979
	• Should be located landward of the ordinary high water or wetland-upland edge and not reflect wave energy so as to destroy productive bottom	Hubbard and Blair 1979
	• Should be designed to avoid interference with littoral drift and natural deposition of sand and sediment	Hubbard and Blair 1979
	• Retain or establish a buffer strip of vegetation between the bulkhead and shoreline	Carrol 1976
	• Material used to backfill bulkheads should not be dredged from aquatic or wetland areas	Hubbard and Blair 1979
	• Shore banks behind bulkheads should be graded back or terraced to control erosion	Hubbard and Blair 1979

Table 3.3-4. Examples of mitigation practices applicable to excavation and fill for construction of highways through wetlands (various sources in Nelson et al. 1982c).

Activity	Mitigation Concept	Reference
Excavation and Filling	● Wetland crossings should be built on elevated structures that preserve natural drainage patterns; pilings are better than fill to ensure passage of water, nutrients, and organisms	Canter et al. 1977; Carrol 1976
	● Pervious fill may be preferred over impermeable solid fill, in combination with culverts	Nelson et al. 1982c
	● Culverts large enough to pass flood flows should be set at depths in highway fill necessary to provide fish passage during low flow	Nelson et al. 1982c
	● Use many smaller culverts as opposed to a few larger culverts to promote freer flow	Mulvihill et al. 1980
	● Sediment traps should be installed to prevent sediment from leaving the site	Hubbard and Blair 1979
	● Stabilize causeway banks and disturbed upland slopes with vegetation or rock armor	Nelson et al. 1982c
	● Construction should be timed to avoid breeding, spawning, and nesting seasons, and to coincide with low flows	Hubbard and Blair 1979
	● Construct terrain under bridges to allow movement of wildlife	Swanson 1979

Table 3.3-5. Examples of mitigation measures for control of wetland filling due to soil erosion and siltation (various sources in Nelson *et al*. 1982c).

Activity	Mitigation Concept	Reference
Soil Cultivation or Disturbance	• Clearing of vegetation for construction should be restricted to what is absolutely essential	Hubbard and Blair 1979
	• Exposed soil should be protected through revegetation, mulching, filter cloth, or riprap armor	Hubbard and Blair 1979
	• Surface roughening (scarification) may be useful in reducing surface runoff over periodically disturbed soils	Nelson *et al*. 1982a Logan 1982
	• Use diversion features such as rock-lined channels, runoff control berms, and terraces to divert runoff from erodable surfaces	Canter *et al*. 1977
	• Incorporate settling basins or retention ponds into storm discharge systems	Banner 1979
	• Provide windbreaks or vegetative buffer strips to reduce soil erosion	Sampson 1979
	• Control overgrazing within wetland interiors and watersheds to reduce erosion	Committee on Impacts of Emerging Agricultural Trends 1982

Table 3.3-6. Examples of mitigation measures for eutrophication from sewage effluents discharged in wetlands (various sources in Nelson _et_ _al_. 1982c).

Activity	Mitigation Concept	Reference
Sewage Treatment	• Pre-treat effluent to remove constituents contributing to eutrophication, particularly phosphorus	Benforado 1981
	• Use holding tanks to allow effluent application after growing season in order to reduce cyclic eutrophication	Benforado 1981
	• Do not apply sewage effluents to wetlands that have poor flushing capabilities	Steen and Ton 1981
	• Vary the points of discharge into the wetland to improve effluent assimilation	Benforado 1981
	• Provide dikes and outflow control structures to avoid undesirable low or high water and to allow periodic flushing	Benforado 1981
	• Culture a plant such as water hyacinth within a primary discharge basin; periodically harvest to remove excess nutrients	Duffer and Moyer 1978

Table 3.3-7. Examples of mitigation measures for control of temporary adverse effects from pipeline installation (various sources in Nelson *et al*. 1982c).

Activity	Mitigation Concept	Reference
Pipelaying Ditching	● Alternate routes around wetlands should be employed for pipeline crossings when possible	Hubbard and Blair 1979
	● Use existing access trails, natural corridors, pipeline rights-of-way and ditches, where possible	Stone *et al*. 1979; Maiero, Castle and Crain 1978
	● Conduct heavy equipment operations atop mats or floating barges	Hubbard and Blair 1979
	● Pipeline ditches should be backfilled as near as practicable to the original marsh elevation with original dredge	Longley, Jackson and Snyder 1981; Hubbard and Blair 1979
	● Pipeline corridors and other disturbed sites should be revegetated with wildlife food and cover crops to prevent erosion	Steen and Ton 1981

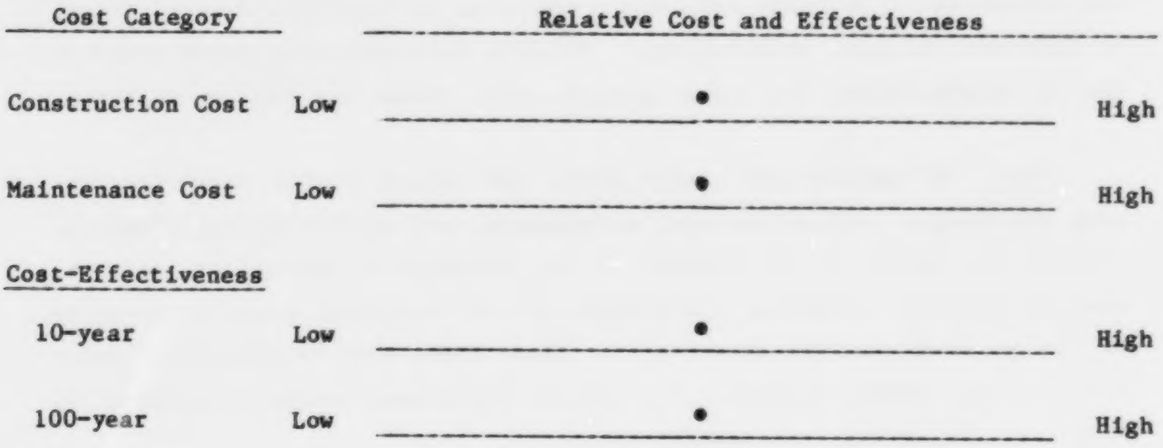
Factor	Reason That Factor Limits Mitigation
Site specific vs. general prescription for mitigation	Standard permit conditions, nationwide or regional permits and Best Management Practices (BMPs) may overlook specific impacts on wetlands.
Application, monitoring, and enforcement of BMPs	Indiscriminate BMP application, monitoring, enforcement may overlook site-specific impacts.
Prevalence of secondary and cumulative impacts	Secondary impacts such as release of toxics during dredging in addition to elevated turbidity often go unnoticed, make it hard to mitigate; cumulative effects may go unnoticed but may be sublethal; mitigation limited to primary effects avoids such impacts.
Technological/management capabilities	Wide variation in ability or willingness of managers to actually implement mitigation effectively.
Cost	Mitigation cost may be required of some developers but not others, resulting in inequities; may make project infeasible; land acquisition costs may be high; maintenance costs may be high; uncertainties of success of mitigation also a factor; long-term maintenance cost/cost effectiveness may be much greater than initial development costs (Figure 3.3-3).

3.3.4.2 Feasibility of Wetland Impact Mitigation

Factors Limiting Success. Various factors can act to limit the feasibility of wetland mitigation activities. The OTA report cites the following factors:

Technical Feasibility of Mitigation Measures. The OTA study noted that some activities may be feasible to mitigate whereas others are not. The potential primary, secondary, and other impacts must be well understood, however before they can be mitigated. Examples of mitigatable

Figure 3.3-3. Hypothetical cost comparison using three different mitigation measures to alleviate disruption of surface and subsurface drainage due to highway construction on wetland fill (from Nelson *et al*. 1982c).



Key to mitigation measures:
● = Culvert through fill
= Bridge on piers
= Pervious fill

effects include removal of contaminated sediments in lake restoration projects (a CG or WWT) example related to WWTP projects would include selection of alternative interceptor routes that produce the smallest amount of direct or indirect wetland habitat disturbance). Activities that are infeasible to mitigate completely are cited as including direct habitat elimination (filling, bulkheading). Off-site restoration or marsh creation can be accomplished, but at a greater cost, which may not be feasible.

Cost. Mitigation costs vary widely and depend on the required planning and design, capital outlays, maintenance, and monitoring requirements. Fencing is listed as an example of an inexpensive mitigation measure, whereas projects involving restoration of old disturbed areas or creation of new wetlands are the most costly. Such costs must be considered relative to the useful economic life of an individual project, however, to determine the actual cost/benefit ratio.

3.3.5 USEPA Indirect Impact Analysis Method

USEPA (Zimmerman, 1974) prepared a manual for determining indirect socioeconomic impacts of sewage treatment facilities construction and operation. The manual includes sections that describe methods to define indirect impacts on water resources and land resources, two impact categories that could directly affect wetlands. The general types of potential indirect effects on wetlands were discussed in Section 2.2. This section summarizes the methods used to address water and land resource impacts presented in Zimmerman (1974).

The overall method presented by Zimmerman (1974) to address indirect impacts is shown in Figure 3.3-4. The initial step is to project the magnitude and direction of population growth, and associated types of development (industrial, commercial, or residential). Indirect impacts on wetlands due to this induced growth may then be determined. Pollutant loadings from non-point runoff may be estimated by use of so-called "pollution coefficients." The coefficients are used to predict changes in pollution levels with and without the proposed waste treatment facility (Figure 3.3-4). The levels of expected pollution are then compared with

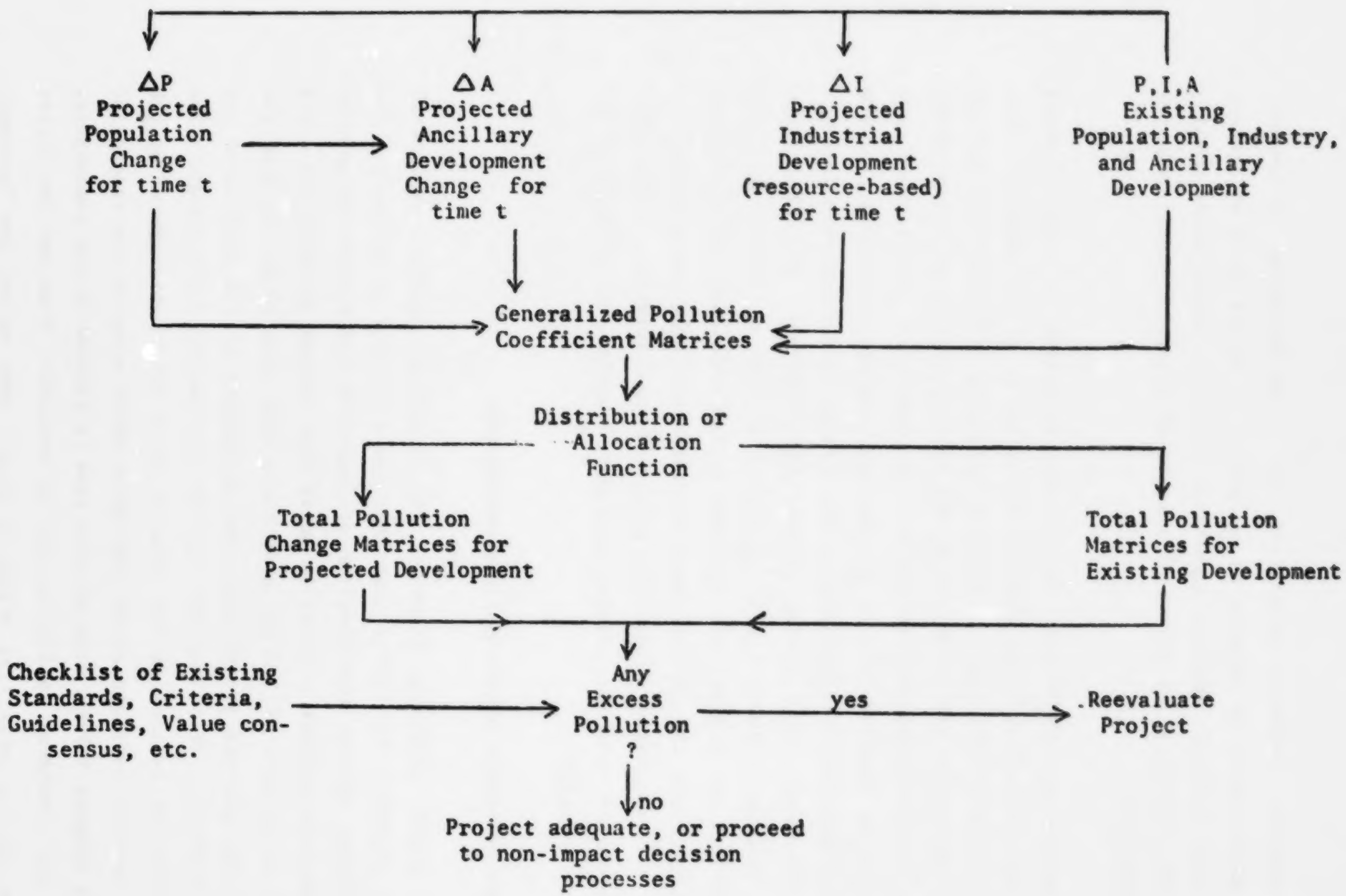


Figure 3.3-4. Method presented by Zimmerman (1974) to assess indirect impacts of wastewater facilities.

various standards, criteria, guidelines, etc... to determine if "excess" pollution might result in impacts on wetlands. It is not clear at present what the term "excess" exactly signifies, however, since water quality standards for discharges or allowable amounts of non-point runoff have not yet been developed.

The "pollution coefficient" is actually expressed in units of waste generated per unit of economic activity (production or employment). This allows estimates of the total amounts of pollution generated per unit of land (i.e., geographic sub-units) to be determined. Pollution ratios under alternative spatial arrangements can also be compared. Coefficients have been developed by Zimmerman (1974) for two major categories (industrial and residential/commercial). Coefficients are further subdivided into "direct" pollution discharge types (point source) and "indirect" pollution types (non-point source). USEPA (1978) presented methods to assess pollution from agriculture and mining, not included in the Zimmerman (1974) report. Appendix I presents the methods used by Zimmerman (1974) to generate the industrial and residential/commercial pollutant coefficients. These coefficients could be used to predict secondary impacts on projects where wetlands are involved.

3.3.6 USEPA Secondary Impact Analysis Methodology

USEPA (1978) published a manual for analyzing indirect impacts of wastewater treatment facilities that included a section on wetlands. The method requires initial determination of long-term projections in population and land-use changes. Possible areas that include wetlands and could be subject to effects of induced growth are then identified. To make the population and land-use projections, the boundaries of the study area are first established. This requires use of specialized terminology. The "service area" is defined as the area in which growth is induced by the treatment facility over and above that which would occur in the absence of the project (Figure 3.3-5). The service area is defined by the communities served by the treatment facilities and is available from the facilities plan. The service area lies within a larger area called the "economic area" (Figure 3.3-5). This may constitute either a standard metropolitan

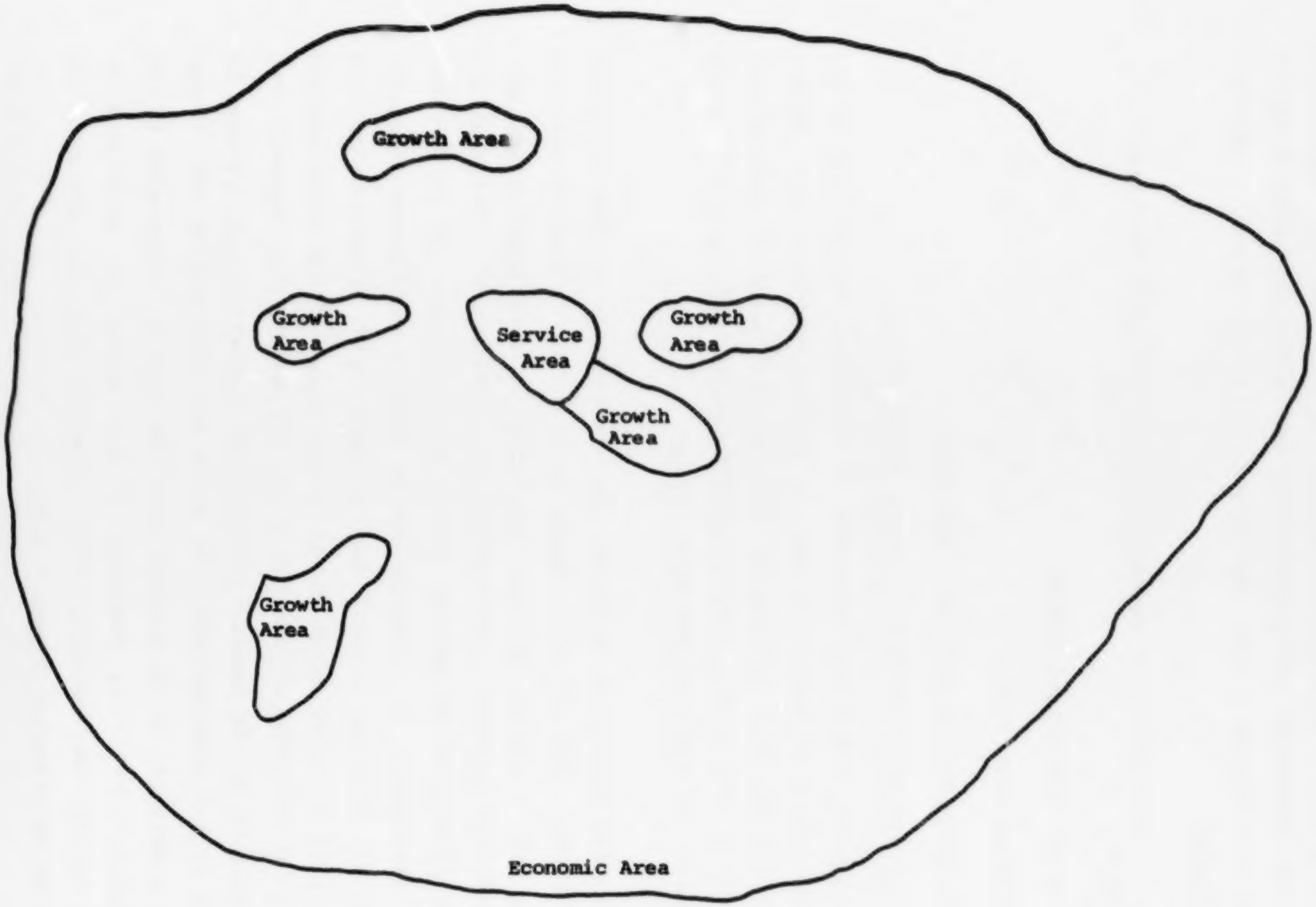


Figure 3.3-5. Definitions of various sub-boundaries within the geographic area affected by 201 wastewater planning (from USEPA 1978).

statistical area, an individual county, or a multiple-county region linked or associated with a city. "Growth areas" are potentially competing areas with similar growth characteristics as the service area, but which would experience any additional development over and above that induced within the service area (Figure 3.3-5). The growth areas have several characteristics, including:

- Similar availability of undeveloped land with good development potential;
- Proximity to developed areas;
- Comparable land prices;
- Shopping/recreation opportunities; and
- Similar community attitudes towards future growth.

A fourth area, termed the "sub-area" is defined as the portions of the economic area likely to experience induced growth (Figure 3.3-6). Determination of the sub-area is usually done on the basis of professional judgment using all the available baseline information. The sub-area is the critical area for determining secondary impacts.

To determine impacts on wetlands, the distribution of these habitats within the economic area are first mapped on an overlay. Possible wetlands that overlap with sub-areas are then identified by superimposing the wetland and sub-area overlays. This allows determination of areas that may be directly eliminated by induced growth or areas that may produce encroachment, hydrologic, or pollutant runoff impacts on adjacent wetlands. The acreage of affected wetland can be determined by planimetry and expressed either as total acres or as a percentage of the total wetland available in the watershed or economic area. The manual also suggests that hydrologic impacts may be roughly estimated by conducting a well survey in the vicinity of the affected area. If wells are very shallow and located adjacent to a wetland, it is probable that the well is replenished by the wetland (Figure 3.3-7). In contrast, if the wetland is recharging an underground aquifer not hydrologically connected with the wetland, the wells would not be affected (Figure 3.3-7).

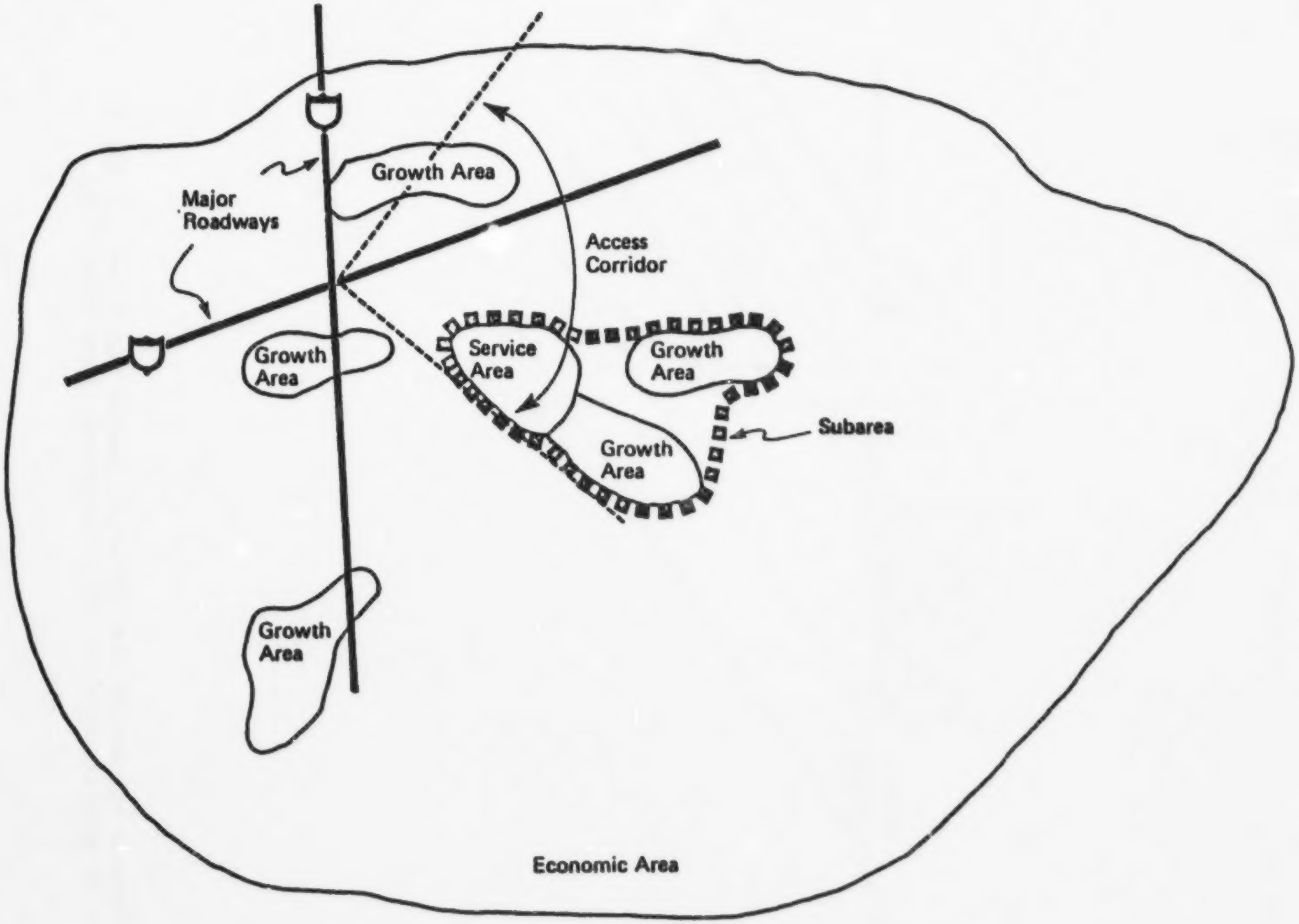


Figure 3.3-6. Illustration of the concept of the "sub-area", or those portions within the economic area which are most likely to be affected by 201 planning (from USEPA 1978).

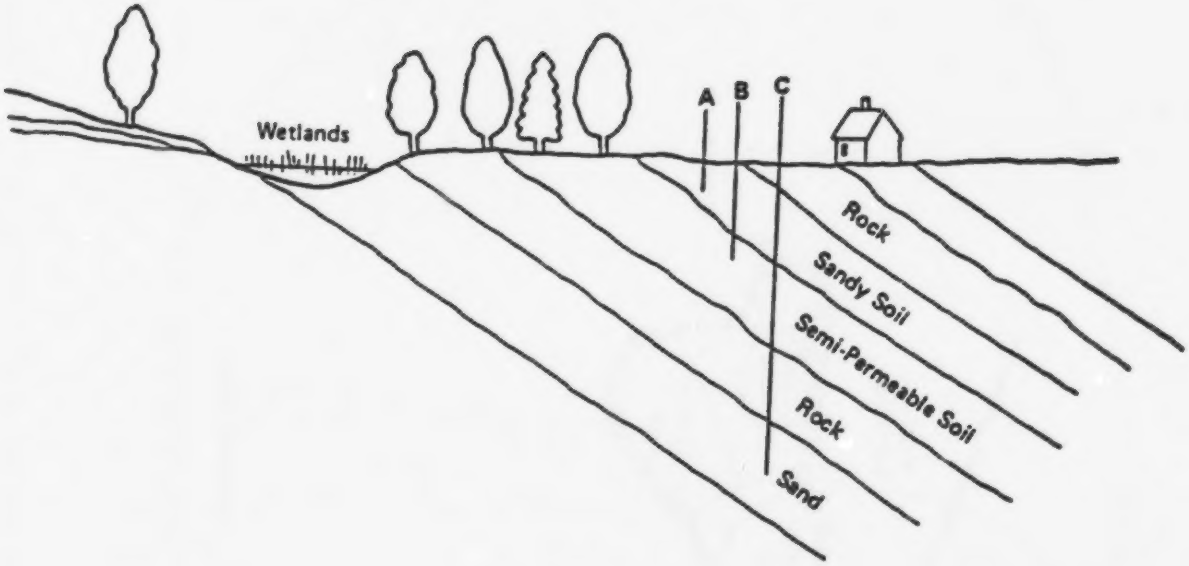


Figure 3.3-7. Example situations whereby wells located near a wetland may or may not be directly hydrologically connected (from USEPA 1978).

3.3.7 State of New Jersey Bureau of Regional Planning Indirect Impact Analysis Methodology

The New Jersey Bureau of Regional Planning (1975) published a methodology for assessing indirect impacts of wastewater treatment facilities construction and operation. The method is outlined in Table 3.3-8, and presented in more detail in Appendix J. Although the method is primarily socioeconomic, it is a comprehensive planning tool and describes means for including wetlands. No specific method is provided for evaluating baseline conditions or for determining the specific types or magnitudes of impacts expected to result on wetlands (see Appendix J). Rather, this method provides a means of identifying situations where induced growth might produce encroachment on wetlands, wetland habitat elimination, or increased runoff and erosion on wetlands within a service area. Since the method is essentially self-explanatory, it will not be discussed further here.

3.3.8 The Ontario Ministry of Natural Resources/Canadian Wildlife Service Methodology

The Canadian government (Ontario Ministry of Natural Resources/ Canadian Wildlife Service 1983) has developed an evaluation system for wetlands south of the pre-cambrian shield. The method provides a means of objectively establishing the functions, values and areal extent of a particular wetland. The document includes a description of the method as well as a users manual. It is a relatively detailed approach which requires a substantial expenditure of labor to complete. The method requires completion by a qualified biologist with knowledge of local flora, knowledge of aerial photographic interpretation of wetland extent and boundaries, and general knowledge concerning wildlife. It also requires a minimum of two weeks of training to become familiar with the method.

The method considers four components of wetland values including: (1) biological values; (2) social values; (3) hydrological values and (4) special feature values. Each value category is rated by the method and assigned a score of from 0 to 250 points. The advantage of such a large "point spread" is that it is more sensitive to subcomponent wetland features, and allows more accurate evaluation of "minor" values (those assigned only a few points). The system also weights scores within each

EXPLANATION OF THE METHOD FOR EVALUATING SECONDARY IMPACTS OF REGIONAL SEWERAGE SYSTEMS

The purpose of investigating the seven categories in these guidelines in the order suggested is to gain an understanding of the growth-induced impacts which may result from each of the alternative systems which have been proposed. It is necessary to determine the probable rate and pattern of growth in the service area which will result from each alternative and then to analyze the impacts of that growth. Following is a summary of the rationale behind the guidelines.

SECTION I

Determine pressure for development. To get an indication of the amount of pressure for development in the area, determine what development has occurred since 1960 and what is happening now. Separate by type of land use. This will help to determine whether or not there will be a high rate of growth once the sewers are in. Trends should be adjusted for short-term influences.

SECTION II

Measure vacant, developable land. To get an idea of how much growth could occur, determine how much vacant, developable land there is. Also indicate natural and physical limitations of the land for development.

SECTION III

Compare proposal with existing plans. To see if the proposed project conflicts in any way with existing plans, compare a map of the service area showing the location of the proposed system with plans and future land use plans of municipalities, counties and the State, including plans for highways, parks, reservoirs, and environmentally critical areas. (Include such agencies as the New Jersey Highway and Turnpike Authorities and the Atlantic City Expressway.)

SECTION IV

Evaluate municipal attitude toward growth. The level of land use planning in an area will be decisive in determining potential secondary impacts so it is necessary to evaluate the quality of the planning effort which is being carried out in each municipality. A checklist of indicators is given with which to measure the degree of commitment to basic planning objectives.

SECTION V

Estimate growth. While it is difficult to estimate growth when counties and municipalities have tended to simply accommodate growth as it comes along rather than setting limits and specifying timed stages for development, this task must be carried out in as enlightened a manner as possible. It is necessary to estimate the amount and pattern of growth which will occur in the ten years after construction. This estimate will be based mainly on previously gathered information, such as the amount of vacant, developable land, municipal policies and attitudes, the pressures for development in the area, and the development trends, e.g., PUDs.

SECTION VI

Measure impact. All the previous steps lead up to this one, which should be considered the heart of the analysis. Using the estimates of the pattern and rate of growth above, describe the potential impacts of this growth on the individual municipalities and the region.

SECTION VII

Weigh alternatives. This section should be a thorough evaluation of the alternative proposals in terms of the long-range impacts discussed in the previous section. If possible it should conclude with a recommended project proposal which would have the least adverse impact while adequately solving the current water quality problems of the area. The possibility that all alternatives represent too large a solution to existing problems should not be ignored.

Table 3.3-8. Outline of method used by the New Jersey Bureau of Regional Planning (NJBRP 1975) to assess indirect sewerage system impacts.

wetland component evaluated according to the importance of each. More weight is assigned to values such as breeding areas or habitats for endangered species, for example. The weighted values were the result of over 2 years of field testing, and consultation with experts. The weighted values have therefore been readjusted and reviewed extensively.

The biological component includes the following three subcomponents: (1) productivity; (2) diversity; and (3) size. Productivity is evaluated by estimating five values, including (1) growing degree days (from established map), (2) wetland soil type (from soil maps and field confirmation) (3) type of wetland (bog, fen, carr, swamp or marsh); (4) site (physiographic type according to Cowardin's method) and (5) nutrient status of surface water (chemical testing of total dissolved solids and conductivity required). Diversity is evaluated by considering number of wetland types present; types of vegetation communities, diversity of surrounding habitat, nature of adjacent wetlands, and interspersion with open water. Size is evaluated by relating extent and quality of the wetland. A detailed summary of the biological evaluation method is included in Appendix L.

The social component of the method evaluates four wetland characteristics, including: (1) resources with cash value (timber, rice, commercial fish, bullfrogs, snapping turtles and fur bearers); (2) recreational activities (intensity of use for hunting; nature study/ appreciation, fishing or boating); (3) aesthetics (rating of landscape distinctness, absence of human disturbance); (4) education and public awareness (frequency of educational use, types of facilities and programs, use for research); (5) proximity to urban areas (distance); (6) ownership/accessibility (degree of accessibility for various types of public or private ownership) and (6) size (correlates size score with other social value scores directly in a table).

The hydrologic component addresses the following four values: (1) flow stabilization; (2) water quality improvement; and (3) erosion control. The flow stabilization evaluation includes making estimates of water detention due to surface area. This evaluation is based on size of catchment basin above wetland in relation to total extent of other bodies of water draining into the wetland, the size of any adjoining lakes or rivers, location/size of detention areas within 30 Km above or below the wetland, land use characteristics and size. The flow stabilization evaluation also includes making an estimate of flow augmentation (based on size of wetland and relative position in the watershed).

The water quality improvement sub-component is evaluated by analyzing: (1) short term nutrient removal capability (soil type; flooding depth and frequency; ratio of emergents to submerged vascular plants; land use); (2) long term nutrient removal capability (based on organic sediment characteristics); and (3) erosion control (erosion buffering and sheet erosion functions). Several hydrologic functions which have been included in other methods were omitted from this method. These include groundwater recharge, role of organic soils in hydrology, surficial geology, and drag effects of vegetation in detaining flood waters. The rationales for these omissions are also provided.

The special features component considers the following wetland values: (1) rarity and/or scarcity; (2) significant features and/or fish and wildlife habitats; and (3) ecological age. Rarity/scarcity is evaluated based on a scale of known relative scarcity of wetlands in different physiographic provinces (regardless of wetland type) (on a scale of 5 to 35, where 35 is very scarce and 5 is not scarce). Also included in this evaluation is a similar estimate for rarity of specific wetland type within each province. Other considerations include individual species rarity, breeding habitat for provincially significant and/or endangered species, traditional migration or feeding habitats for endangered species, and regionally important species.

The evaluation of significant features and/or fish and wildlife habitat includes consideration of: (1) nesting colonial waterbirds (known nesting/feeding areas and history of nesting); (2) winter cover for wildlife; (3) waterfowl staging; (4) waterfowl production; (5) migratory passerine stopover area; (6) significance for fish spawning and rearing; and (7) unusual geological or surficial features. Items 2 through 6 are based on an estimate of whether the wetland is of national (provincial), regional or local significance, and the relative value of each function at these levels.

The ecological age component is based on the assumption that systems that require long periods of time to develop ecologically would also take the longest time to recover or restore. Under this assumption, bogs are weighted the highest, fens next highest, swamp/carrs the next highest, and marshes the lowest.

As a means of summarizing the Canadian method, the final checklist as it has been developed is included here as Appendix M.

4.0 CONCLUSIONS AND RECOMMENDATIONS

4.1 Conclusions

The objectives of the present study were to review the existing literature concerning available methodologies to assess baseline conditions within wetland ecosystems and impacts of CG related activities on wetlands. The ultimate objective of USEPA Region V is to use the information assembled in this review to develop a method that can be used by state agencies, facilities planners and other organizations in screening adverse effects on wetlands that potentially could result from implementation of a given facilities plan (the method could also be used for other types of projects). Identification of potentially adverse impacts (red flags) would allow determination of issues that would lead to the requirement of more detailed, site-specific studies. Therefore, the screening methodology would not involve extensive quantitative analysis.

The need for such a methodology has arisen because of the great differences in the scope and emphasis of environmental assessments of wetlands prepared during the facilities planning process in the past. In many instances, the numerous biological, physical-chemical and social values associated with individual wetlands potentially affected by wastewater treatment developments have not been identified. A methodology is therefore required that objectively screens a broad range of wetland values and functions and that accurately flags potential effects of a facilities plan on these values and functions. This approach will help fully address NEPA concerns and avoid violation of the various laws and regulations that protect wetlands from damage or degradation (including the Clean Water Act, two executive orders, and other similar laws or regulations).

On the basis of the literature review in Section 3.0, it can be concluded that a large number of methodologies for assessing various aspects of wetland values and functions have been developed. No single method reviewed, however, meets the requirements of a quick screening technique to determine a broad spectrum of wetland values and functions and the potential for adverse effects of construction grant-related activities. The vast majority of the methods reviewed deal with site-specific means to evaluate baseline ecological functions. These methods (such as HEP or HES) are highly detailed and require a significant amount of labor (although both HEP and HES can be greatly scaled down). The method developed by Adamus (1983) most closely approximates the screening method required by USEPA Region V states for facilities planning, because it determines the values and functions of a wide variety of wetland characteristics, including ecology, soils, hydrology and recreation. However, in its present state the method of Adamus (1983), although defined as a rapid assessment technique, is in reality rather lengthy and requires several days to complete. It would thus be feasible for use primarily only for major projects. The State of Wisconsin is currently modifying this method so that it is not so extensive. The WDNR method should be obtained and reviewed for possible adaptation for use by other states since it addresses a relatively complete range of wetland values and functions. All other methods reviewed in the present study, however, dealt with a limited number of wetland features of one general type or strictly with ecological characteristics.

An additional conclusion is that no methodologies have yet been developed that specifically address the detailed indirect cumulative impacts of induced growth on wetlands within the "economic area" affected by such growth (see Section 3.3.7). Methods developed to date have included only a very general evaluation of possible effects, such as the number of acres of habitat directly eliminated, possible hydrologic impacts, or "presence or absence" criteria. Secondary impacts, however, are typically the most significant result of facilities plan implementation. This is because induced growth affects a much larger geographical area than the actual habitat eliminated or disturbed by construction and operation of a waste treatment system. Methods are available for determining the nature and extent of expected population increases and land use changes resulting from induced growth, as well as the impacts of such changes on water quality resulting from increased non-point erosion and sedimentation, industrial activity, or changes in point discharges. What is now required is a means to screen such impacts and link them directly to the possible effects they may have on wetlands. An additional area not typically included in evaluating the effects of facilities plans on wetlands is the subject of direct cumulative impacts. According to definitions used in the present literature review, direct cumulative effects differ from indirect cumulative effects of induced growth in that the latter deal only with the economic area affected by an individual waste treatment system. Direct cumulative effects would include the total combined primary impact of two or more individual treatment systems within a larger geographical area or basin encompassing several economic areas (see Section 3.3.7 for definition of the term "economic areas"). Both direct and indirect cumulative impacts are difficult and time-consuming to evaluate, however, because of the larger geographic areas involved and the consequent requirement of more labor and resources to complete the analysis. Nevertheless, facilities planning potentially could have adverse cumulative effects on wetlands and assessment of this type of effort should be incorporated at some level into the proposed screening methodology.

4.2 Recommendations

4.2.1 Incorporation of Screening Method into Facilities Planning

A methodology needs to be developed that will enable agency staffs, planners and/or their consultants to evaluate baseline conditions and determine potential adverse impacts on wetlands during the course of facilities planning. A possible outline for the method was presented in Figure 1.2-1. Whatever method is developed, it is recommended that it be integrated into the planning process at an early phase. The method of Reed and Kubiak (1983) who developed a means for incorporating a wetland/wastewater discharge review process into facilities planning, could also be modified and used. Figure 4.2-1 summarizes their approach which is based on the "degradation" concept. Because it represents the only published attempt to date that concerns the integration of legal, regulatory, and administrative constraints into the process of wetland impact evaluation, the approach is briefly outlined here (a similar logical procedure could be developed for construction grant projects in general).

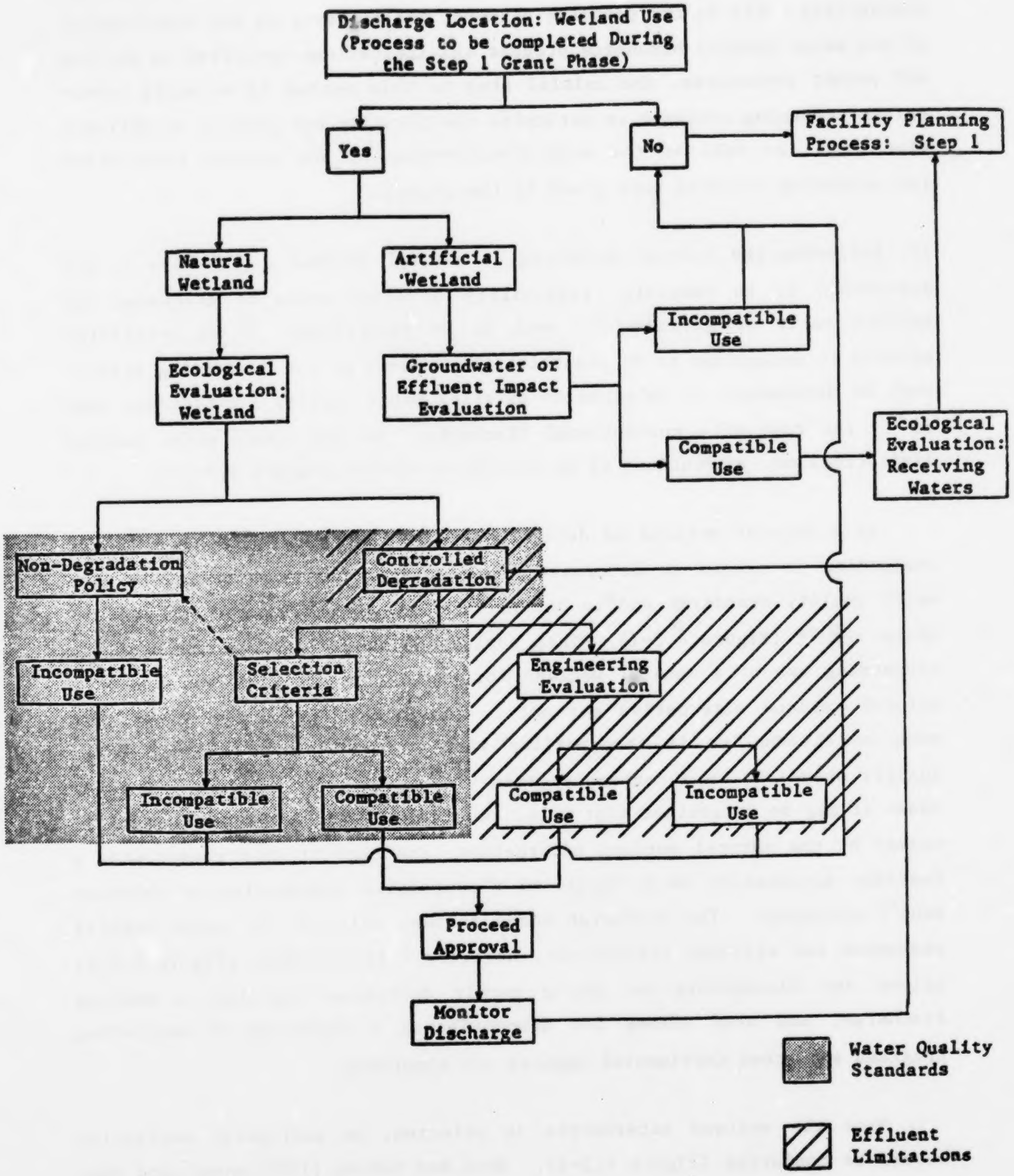


Figure 4.2-1. Method used by Reed and Kubiak (1983) to incorporate wetland evaluation into the facilities planning process.

The Reed and Kubiak method provides a means of determining discharge suitability early in the planning process, and is based on the requirements of the water quality standards process and limitations specified in Section 402 permit procedures. The initial step in this method is to apply appropriate screening criteria to determine the quantity and quality of effluent discharged, as well as the cost-effectiveness of the wetland alternative (no screening criteria were given in the paper).

If, following the initial screening, a natural wetland alternative is not determined to be feasible, feasibility of other modes of discharge (to surface water or groundwater) need to be identified. If an artificial wetland is determined to be feasible, the impacts on the "receiving waters" must be determined in relation to existing water quality limitations, just as in the case of a conventional discharge. In some cases water quality limitations may prevent use of an artificial system (Figure 4.2-1).

If a natural wetland is determined to be feasible, then an ecological evaluation is needed to determine if this alternative is compatible with water quality standards and to determine if adverse impacts to the wetland would result (Figure 4.2-1). This evaluation should precede the decision concerning use of a natural wetland for wastewater application. Use of a natural wetland alternative may not be feasible if it is determined that such an alternative is incompatible with the maintenance of high water quality standards in a particular receiving stream, for example. In other cases it may be determined that water quality will not be degraded significantly by the natural wetland alternative, and that it thus constitutes a feasible alternative as a regulated ("controlled degradation or enhancement") discharge. The discharge needs to meet criteria for water quality standards and effluent limitations, however, this procedure (Figure 4.2-1) allows for flexibility in making permit decisions regarding a wetland discharge, and also allows for discontinuing a discharge if monitoring programs show that detrimental impacts are occurring.

Once the wetland alternative is selected, an ecological evaluation should be conducted (Figure 4.2-1). Reed and Kubiak (1983) concluded that the evaluation should determine:

- Areal extent and boundaries of the affected wetlands;
- Existing ecological functions of the receiving wetland, and importance of the wetland to the surrounding watershed;
- Types and quality of plant and animal communities;
- Existing government management programs that might involve the wetland; and
- Existing regulatory programs that apply to the wetland.

The evaluation of the existing features of the wetland should include characterizations of the following factors:

- Surface water and groundwater quality;
- Hydrologic regime (especially storm flow characteristics and groundwater recharge characteristics);
- Flood control, water storage and aquifer yield during low flow periods.
- Shoreline erosion/protection characteristics provided by the wetland; and
- Overall ecological quality (species diversity and health; potential recreational, research, and educational uses; and socioeconomic values).

To complete the evaluation, appropriate field studies can be performed. These should include measures of plant and animal species composition, abundance, and diversity. Methods for performing such detailed inventories are presented in Reed and Kubiak (1983) and in USEPA (1983). The results of the ecological evaluation can be used during the course of the facility planning process to provide a detailed basis for determining potential impacts on the receiving wetland, and for establishing the acceptability of the discharge.

4.2.2 Baseline Evaluation: Screening Method Requirements

The screening method must encompass a broad range of wetland values and functions in order to be as objective as possible. The majority of methods used to date have focused on one or only a few wetland values and functions. The screening method should allow for a complete assessment of the baseline characteristics and their interaction, so that potential impacts can be readily identified. It is therefore recommended that the following values and functions be included in the screening methodology:

- Groundwater recharge capability;
- Groundwater discharge capability;
- Surface water discharge features (quality, quality);
- Flood storage potential;
- Flood desynchronization potential;
- Shoreline stabilization function;
- Sediment trapping function;
- Nutrient retention/removal functions;
- Food chain support;
- Aquatic habitat value (quantity/quality);
- Terrestrial habitat value (quantity/quality);
- Uniqueness/rarity in watershed and region;
- Historical/cultural value (including archaeological resources);
- Presence of rare/threatened/endangered plants or animals (state and federally listed); and
- Outstanding geomorphological features.

The specific means of screening a given wetland for the above values and functions are not yet developed. Adamus (1983) presents a relatively high labor-intensive method of quantifying many of the above characteristics, but a low labor-intensive method has yet to be created that addresses all of these functions and values (possibly the WDNR method will meet this requirement). Such a method could be developed by modifying and/or combining desirable features of the various methods reviewed in Section 3.0. Nelson et al. (1982c) recently developed a state guidelines manual for evaluating dredge and fill projects. The procedure presented in the USCOE manual is outline in Appendix K. Also included in Appendix K is a copy of the field report sheets used by the biologist who conducts the field survey. Table 4.1-1 provides a list of sources of information concerning wetlands which could be utilized in the baseline evaluations.

4.2.3 Impact Analysis: Screening Method Requirements

Once the baseline characteristics (functions, values, areal extent) of the wetland were established, a second step could be developed in which potential impacts of facilities plan implementation were screened. The screening impact analysis should provide a means of providing an overview of primary, secondary (induced growth) and cumulative impacts of facilities

Data Source	Information Displayed	Scale	Uses	Sources	Cost
USGS Topographic Maps (7½ & 15')	Topographic contours, latitude and longitude, township and range, major roads, railroads, utility lines, contours, water bodies, houses, town names, county and town boundaries, vegetated and non-vegetated wetlands.	1"=2000'	1. Enlarged for use as wetland and floodplains base maps. 2. Interim wetland maps. 3. Watershed boundaries. 4. Source of topographic information for calculating floodplain and floodway boundaries, erosion areas, slope areas.	USGS Geological Division	$.75-.95 a sheet
SCS Soil Survey Maps	Countywide surveys depicting soil types (areas identified as potential wetlands should be field checked for draining or filling).	1"=2000' 1"=1320' 4"=1 mile	1. Mapping of wetland, floodplain, slope, erosion, prime agricultural land, forestry and mineral resource areas. 2. Determination of soil suitability for on-site waste disposal. 3. Determination of soil structural bearing capacity.	SCS USDA	Local units get field sheet (aerial photos) & 1 map free; extra copies cost a few dollars.
State Wetlands, Floodplain, Geologic Maps	Wetland and floodplain boundaries. Varied depending on state and type of area.	1"=2000' to 1"=100'	1. Interim or permanent regulation of areas.	State wetland and floodplain programs	Varied
FEMA, Corps of Engineers Flood Hazard Maps	"Flood prone" areas. Standard project floodplain, 100 year flood elevation, wetland boundaries.	Range from 1"=500' to 1"=1000'	1. Used as zone maps for floodplain zoning and other regulation.	Army Corps of Eng. Floodplain Management Services, USGS, SCS, FEMA	Free
USGS Hydrologic Investigations Atlas; Hydrology & Water Resources Maps	Each map is different-may contain wells, test holes, bedrock, groundwater info., recharge areas, water quality.	1"=2000'	1. Determine groundwater flow. 2. Determine aquifer recharge areas.	Geological Division Distribution Office	Less than $2/sheet
Local Subdivision Maps	Dimensions of property, roads, sewers, size and location of houses, and topographic contours, boundaries of watercourses. Wetland and floodplain boundaries (some circumstances).	1"=40' 1"=60'	1. Help determine precise sensitive area boundaries (some instances).	Municipal Offices	Varied
Air Photos: USGS, USDA, Other Sources	Roads, houses, vegetation, topography, watercourses, structures, fills, flooding, etc. (all features visible from air).	Varied: 1"=2000' common	1. Map wetland, floodplain boundaries. 2. Evaluate development proposals.	USGS, USDA, state transportation offices, consultants	Often free
Surficial Geology	Everything on USGS topographic maps plus geological deposits, bedrock, fill sites.	1"=2000'	1. Determine groundwater flow systems. 2. Determine bedrock. 3. Map mineral resource area.	USGS Geological Division, Geological and Water Supply Report & Maps	Less than $2/sheet
Town, City, County, Borough Zoning Maps	Varied. Information can include road, property lines, zoning district, floodplain and wetland boundaries.	Range from 1"=500' to 1"=1000'	1. Determine existing uses. 2. Determine compatibility of proposed wetland uses with zone classification and adjacent uses. 3. Use as base maps (or sensitive area mapping).	Municipal Offices	Varied
Assesser Maps, Plat Books	Property lines, owners' names, easements, roads, buildings.	1"=100' or 1"=200'	1. Determine ownership, boundary lines.	Each town, city, county	Varied
USFWS Wetland Inventory Maps	Wetland types by water regime, vegetative regime, etc.	Varied: 1"=2000' Common	1. Determine wetland boundaries, identify wetland types.	USFWS Regional Offices	Varied

Table 4.1-1. Sources of wetland data.

plan implementation on wetlands. All impacts analyzed should relate to possible alterations in defined baseline values and functions (see above). The initial step in analyzing these effects would identify:

- The amount and quality of wetland, if any, to be directly eliminated or encroached on by alternative treatment plant sites and interceptor routes;
- The amount and quality of wetlands to be eliminated or encroached on within sub-areas in which induced growth is most likely to occur as a result of implementation of various facilities plan alternatives; and
- The amount and quality of wetland to be eliminated or encroached on due to both primary and secondary impacts within an "economic area" and the surrounding river basin or geographical area (i.e., cumulative effects).

The first item listed above provides information concerning how alternative treatment system construction and operation plans will directly affect existing wetlands (i.e., primary impacts). Alternatives could be screened and evaluated initially relative to their potential effects. This can be done by superimposing proposed facility overlays onto wetland maps. The second item is probably the most important, since induced growth will usually have greater impacts (secondary impacts) than treatment facilities themselves. Secondary impacts require some type of projection of population and land use changes. A rough idea of secondary impacts of various alternatives could be obtained by superimposing overlays of sub-areas of induced growth (interceptor routes into undeveloped land) over wetland maps for the affected economic area. This information could be obtained from existing and proposed zoning, including building permit applications, and building plans on file. Cumulative impacts are much harder to estimate because of the larger geographical area involved. A method similar to that presented in Galloway et al. (1978) could possibly be used, but such methods are costly and labor-intensive.

The screening method would identify which wetlands within an economic area would be eliminated directly or would be encroached upon by primary and secondary development caused by a particular alternative. The screening method also should identify which of the various functions and values identified in the baseline review would be altered, and the possible magnitude of such impacts. For example, if the wetland of concern was identified as having a highly valuable function as an aquifer recharge area or perhaps as a cultural or recreational resource, this would be recognized and means of avoiding such impacts could be incorporated during the planning phase (possibly involving choosing an alternative cost-effective treatment facilities configuration that does not impact the wetland).

The screening method should also enable the planning or agency staff to identify available scientific methods to study particular issue areas in depth at a later date. If, for example, the effects of a WWTP discharge on a receiving wetland were an issue, the screening process would provide references concerning possible more detailed scientific methods to assess such impacts (these were summarized in USEPA, 1983). These methods could be referenced during the planning process and incorporated into a construction or post-construction monitoring program.

The results of the wetland screening evaluation could be incorporated directly into the Facilities Plan if no adverse impacts were predicted. The agency would then have a more sound basis for making an objective decision with regard to implementing the project. If adverse impacts on valuable wetlands were predicted, the agency could request that more detailed issue-specific studies be conducted (for example studies of the effects of wastewater discharge on ecology, the affects of hydrologic changes on aquifer functions, or effects on protected species). The results of these more detailed issue specific studies could be incorporated into the facilities plan, and used as the basis for determining either which alternative should be funded or which possible mitigative actions should be used (Figure 1.2-1).

4.2.4 Recommended Screening Method

Figure 1.2-1 presented a general outline of how a screening method could be incorporated for use in permitting and planning activities within USEPA Region V. It is recommended that such a method be developed and that it then be incorporated into the facilities planning process. The method could be developed by utilizing the most advantageous features of the approaches presented in Section 3.0, and then integrating this into the overall planning process, in a manner similar to that recommended by Reed and Kubiak (1983). This will lead to improved facilities planning decision-making relative to effects of wastewater treatment projects on valuable wetland resources in Region V.

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APPENDIX A

Summary of construction related impacts to wetlands as identified by previous studies

Schuldiner et al. (1979) summarized the potential effects of highway construction on wetlands. The basic types of impacts identified are as follows:

- Impacts associated with surface flows
  - Changes in mean water level
  - Change in periodicity of flooding
  - Changes in circulatory patterns

- Impacts associated with sub-surface flows
  - Alteration of local water tables

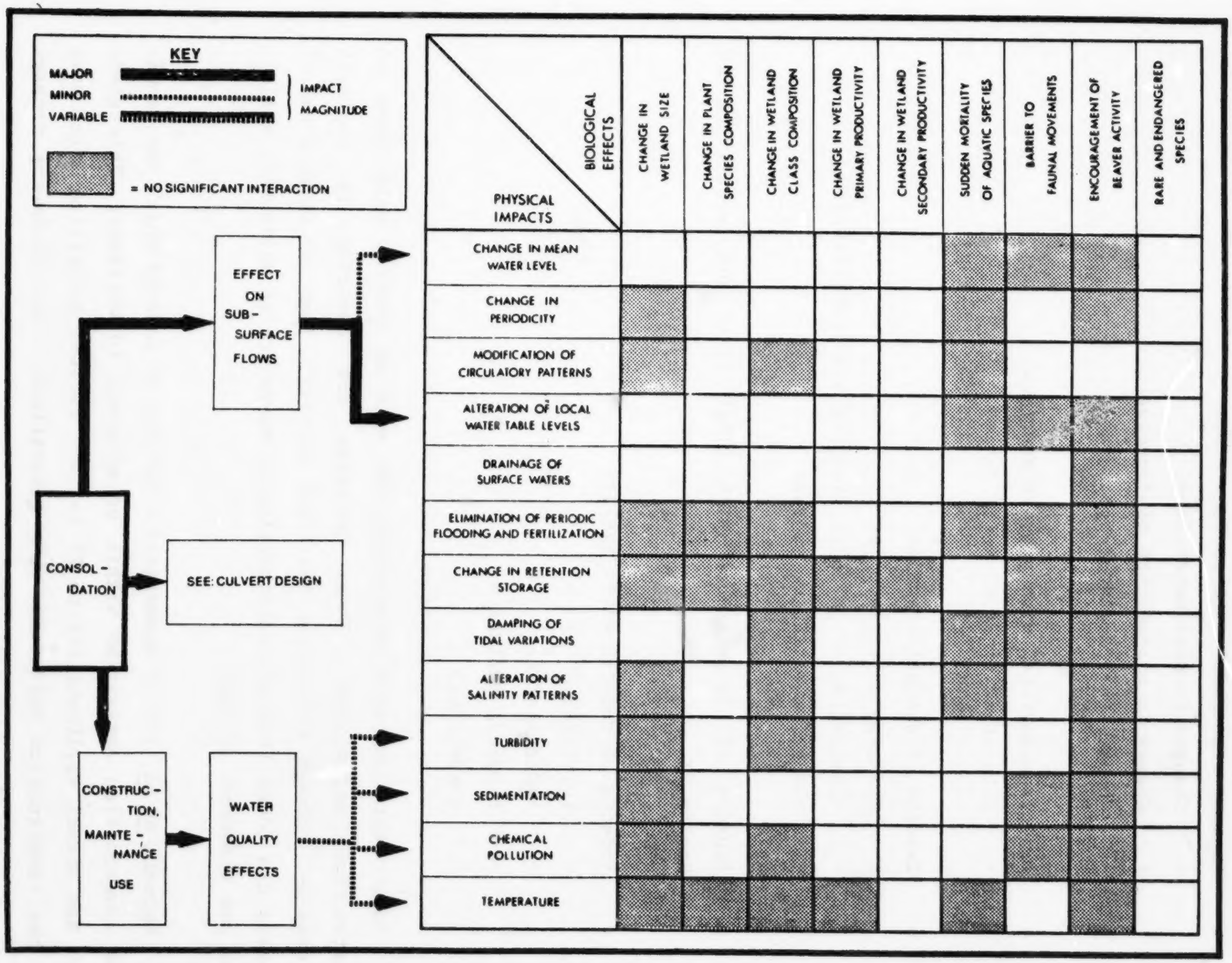
- Impacts of channel creation
  - drainage of surface water
  - elimination of periodic flooding and fertilization
  - change in retention storage

- Impacts of interference with tidal flow (not applicable to Region V)

- Impacts of reduced water quality
  - turbidity
  - sedimentation
  - chemical pollution
  - temperature

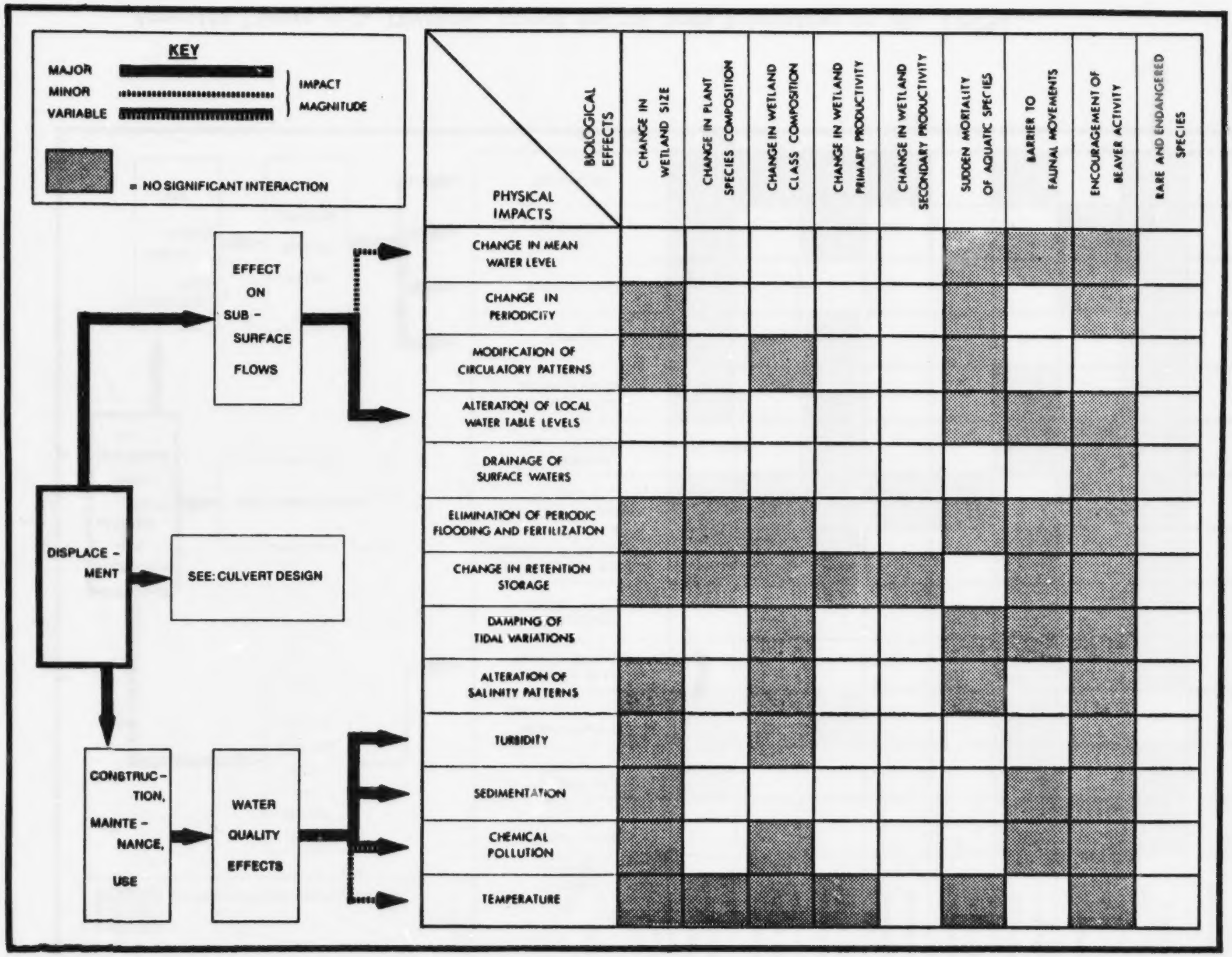
Impact matrices were constructed for each of several main types of construction activities. These matrices are depicted in Appendix Figures A-1 through A-7 (minus the tidal matrix). Many of these types of impacts can occur from the construction or operation of wastewater collection and treatment systems.

Darnell et al. (1976) summarized a variety of impacts which may result from construction activities within or adjacent to wetlands. This study also has direct applicability to FP (or CG) related activities since most of the construction activities are generalized. The following general types of activities were analyzed:



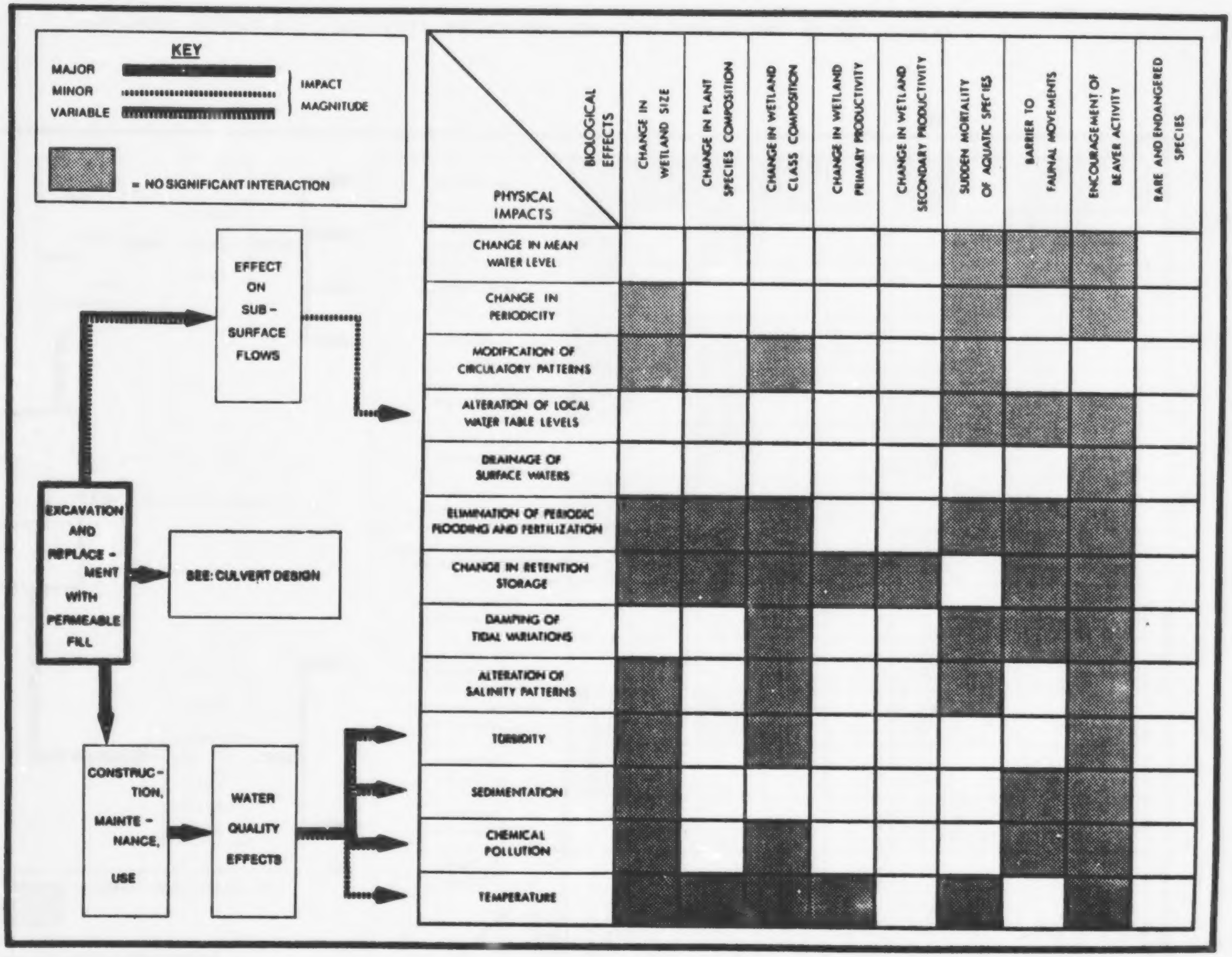
PHYSICAL IMPACTS \ BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨	▨	▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-1. Physical impact matrix from Schuldiner et al. (1979).


KEY
MAJOR
MINOR
VARIABLE
IMPACT MAGNITUDE
▨ = NO SIGNIFICANT INTERACTION
DISPLACE - MENT
EFFECT ON SUB - SURFACE FLOWS
SEE: CULVERT DESIGN
CONSTRUC - TION, MAINTE - NANCE, USE
WATER QUALITY EFFECTS

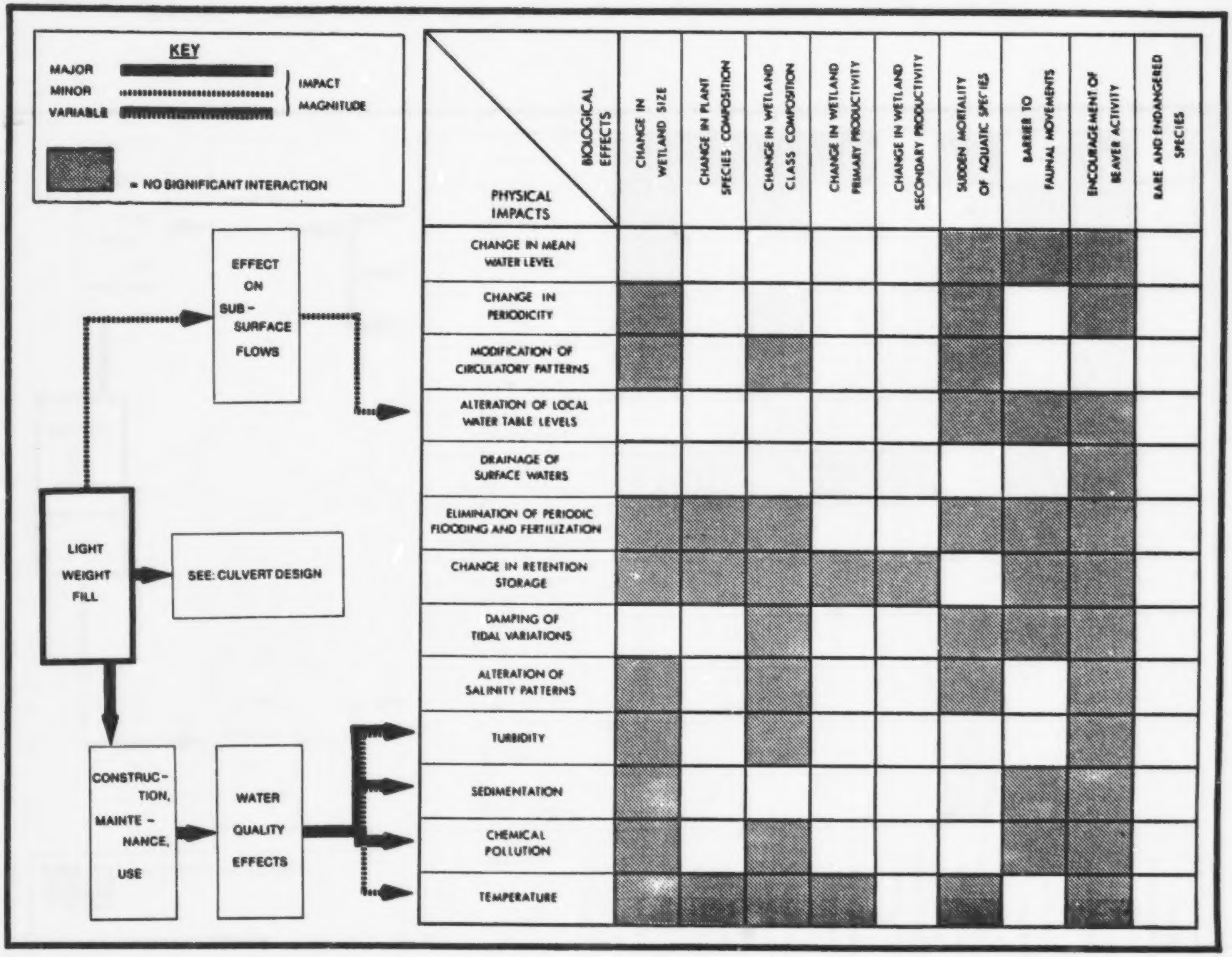
PHYSICAL IMPACTS \ BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨		▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-2. Physical impact matrix from Schuldiner et al. (1979).


KEY
MAJOR
MINOR
VARIABLE
IMPACT MAGNITUDE
= NO SIGNIFICANT INTERACTION
EXCAVATION AND REPLACE - MENT WITH PERMEABLE FILL
EFFECT ON SUB - SURFACE FLOWS
SEE: CULVERT DESIGN
CONSTRUC - TION, MAINTE - NANCE, USE
WATER QUALITY EFFECTS

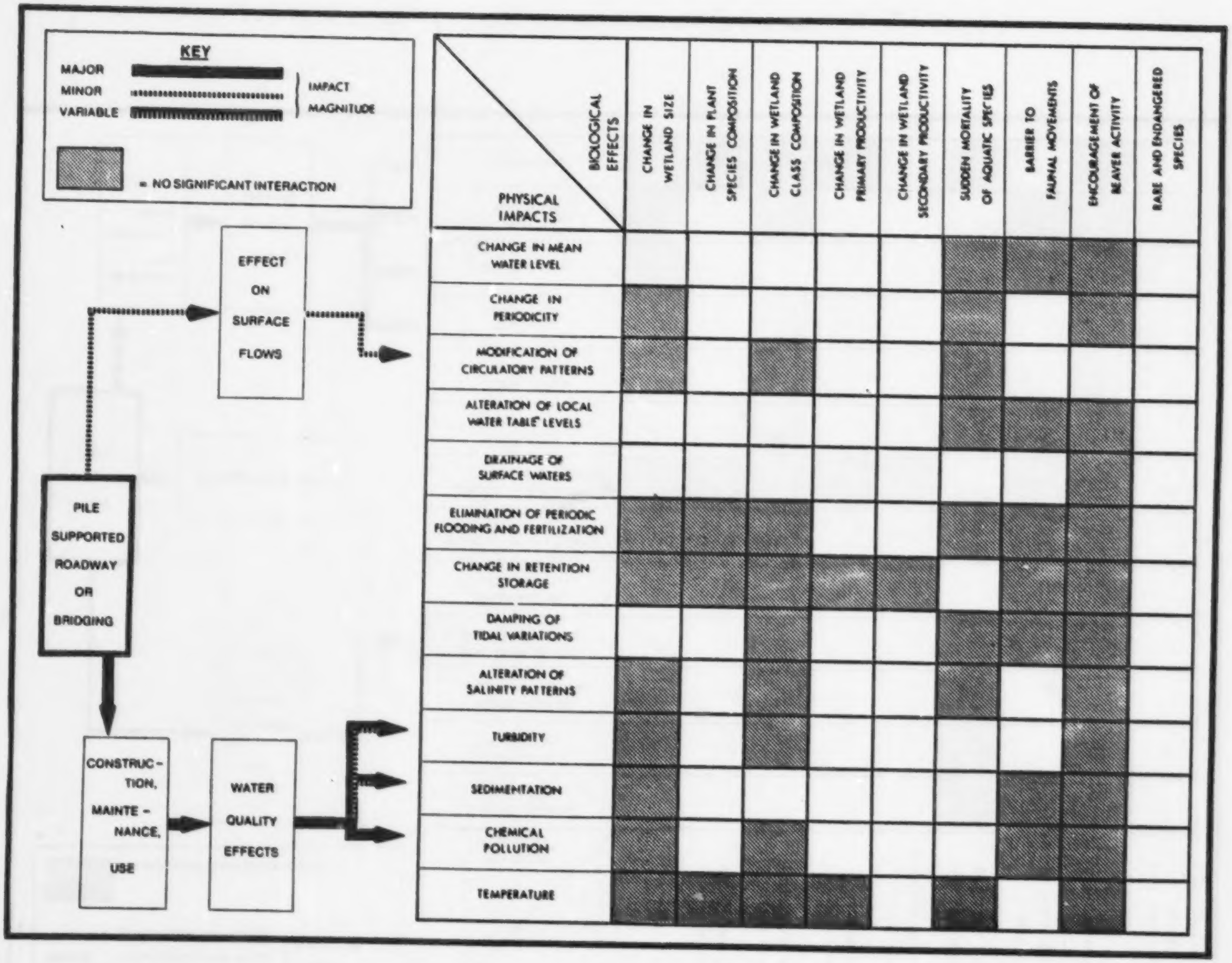
PHYSICAL IMPACTS / BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨		▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-3. Physical impact matrix from Schuldiner _et_ _al_. (1979).



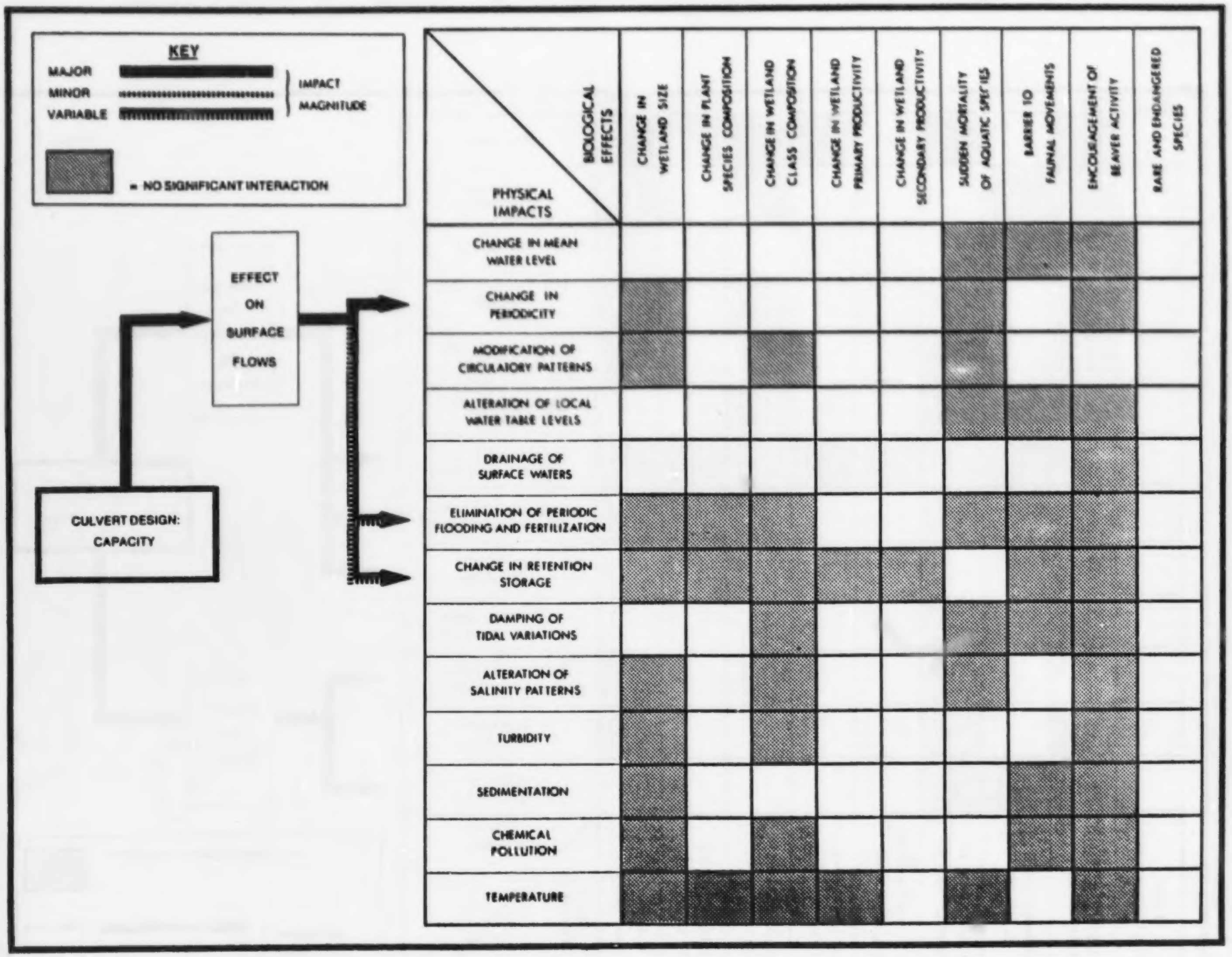
PHYSICAL IMPACTS \ BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨		▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-4. Physical impact matrix from Schuldiner *et al*. (1979).


KEY
MAJOR
MINOR
VARIABLE
IMPACT MAGNITUDE
= NO SIGNIFICANT INTERACTION
PILE SUPPORTED ROADWAY OR BRIDGING
EFFECT ON SURFACE FLOWS
CONSTRUCTION, MAINTENANCE, USE
WATER QUALITY EFFECTS

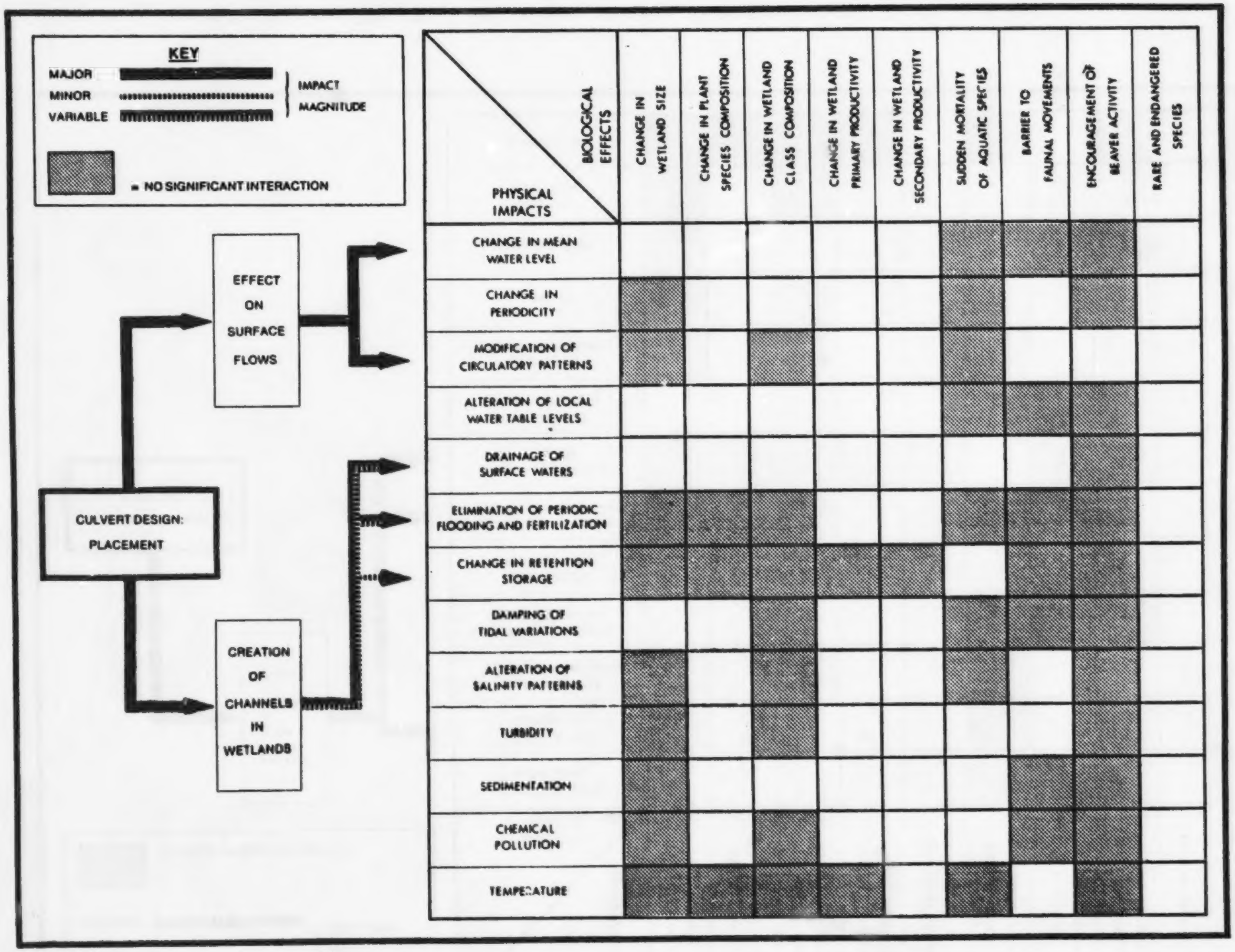
PHYSICAL IMPACTS \ BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨		▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-5. Physical impact matrix from Schuldiner _et_ _al_. (1979).



PHYSICAL IMPACTS \ BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨		▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-6. Physical impact matrix from Schuldiner et al. (1979).


KEY
MAJOR
MINOR
VARIABLE
IMPACT MAGNITUDE
= NO SIGNIFICANT INTERACTION
CULVERT DESIGN: PLACEMENT
EFFECT ON SURFACE FLOWS
CREATION OF CHANNELS IN WETLANDS

PHYSICAL IMPACTS \ BIOLOGICAL EFFECTS	CHANGE IN WETLAND SIZE	CHANGE IN PLANT SPECIES COMPOSITION	CHANGE IN WETLAND CLASS COMPOSITION	CHANGE IN WETLAND PRIMARY PRODUCTIVITY	CHANGE IN WETLAND SECONDARY PRODUCTIVITY	SUDDEN MORTALITY OF AQUATIC SPECIES	BARRIER TO FAUNAL MOVEMENTS	ENCOURAGEMENT OF BEAVER ACTIVITY	RARE AND ENDANGERED SPECIES
CHANGE IN MEAN WATER LEVEL						▨	▨	▨	
CHANGE IN PERIODICITY	▨					▨		▨	
MODIFICATION OF CIRCULATORY PATTERNS	▨		▨			▨			
ALTERATION OF LOCAL WATER TABLE LEVELS						▨	▨	▨	
DRAINAGE OF SURFACE WATERS								▨	
ELIMINATION OF PERIODIC FLOODING AND FERTILIZATION	▨	▨	▨			▨	▨	▨	
CHANGE IN RETENTION STORAGE	▨	▨	▨	▨	▨		▨	▨	
DAMPING OF TIDAL VARIATIONS			▨			▨	▨	▨	
ALTERATION OF SALINITY PATTERNS	▨		▨			▨		▨	
TURBIDITY	▨		▨					▨	
SEDIMENTATION	▨						▨	▨	
CHEMICAL POLLUTION	▨		▨				▨	▨	
TEMPERATURE	▨	▨	▨	▨		▨		▨	

Appendix Figure A-7. Physical impact matrix from Schuldiner et al. (1979).

- Onsite activities prior to construction
- Construction of access roads
- Establishment of construction camp
- Materials storage
- Clearing of site
- Earth excavation and fill
- Foundation preparation and construction
- Disposal of excess excavated materials
- Major construction activity
- Site restoration and clean-up.

A set of specific types of construction activities falling under these general headings was actually reviewed in Darnell et al. (1976). The physical and chemical effects of each were assembled in a matrix against one another and these were then translated into biological effects using factor rank analysis. Four major classes of activities were found to have the most significant impacts. These included: (1) general lowland construction; (2) mineral extraction; (3) dam construction; and (4) dredging and spoil placement. The most important impacts on riparian communities included:

- Loss of riparian habitat
- Removal of vegetative cover
- Removal of topsoil
- Increased surface runoff
- Increased soil erosion
- Lowered water table.

Within the wetland environment the most important effects (listed by category) were as follows:

Circulation

- Loss of wetland habitat
- Reduction of habitat diversity
- Modification of normal seasonal flow patterns

- Drastic fluctuation in water levels and flow rates
- Reduction in flow volume
- Increased downstream flooding.

Sediment

- Creation of canals in swamps and marshes
- Increase in turbidity
- Increase in sedimentation
- Clogging of stream riffles
- Filling of pool areas
- Alteration of bottom topography

Chemical and Physical Properties

- Reduction in light penetration
- Elevation of temperature
- Modification of natural chemical composition
- Increased oxygen demand
- Addition of chemical pollutants
- Build-up of bottom pollutants
- Increase in salinity (in coastal estuaries, marshes, and swamps)

Appendix Tables A-8 through A-12 summarize available information concerning physical and chemical effects of the various construction activities on wetland. Appendix Figures A-13 through A-19 summarize the biological effects via impact factor trains.

Nelson et al. (1982c) provided an overview of impacts of dredge and fill activities on inland wetlands. Figures A-20 through A-22 summarize the results of this discussion.

Appendix
Table A-8. The primary physical and chemical effects of various types of construction activities on the riparian and wetland environments of the United States.

Construction activity / Physical and chemical effects								Dam construction								Dredging & spoil placement					
	Preconstruction activities —	Impervious surfacing & earthwork —	Drainage ditching —	Building construction —	Open air industrial plant constr'n.	Drainage structures —	Tunnel construction	Mineral extraction on land	General effects	Upstream effects	Near downstream eff.	Far downstream eff.	Estuarine effects	Marine effects	Fill construction	Bridging	Gen. & immed. effects	Channelization effects	Riparian effects	Bay & estuarine eff.	Marshland effects	Waterway margin constr.
RIPARIAN ENVIRONMENT																						
Loss of riparian habitat	x	x	x	x	x	x	x	x	x	x				x	x	x	x		x		x	x
Removal of vegetative cover	x	x	x	x	x	x		x		x												
Removal of topsoil		x	x	x	x	x		x														
Drainage of riparian wetlands																			x			
Increased surface runoff	x	x	x	x	x	x		x														
Interference with surface drainage																					x	
Elimination of floodplain flooding								x			x											
Inundation of floodplains								x		x		x										
Increased hazard of flooding																		x				
Increased soil erosion	x	x	x	x	x	x		x		x									x		x	
Loss of soil minerals		x						x		x												
Reduction of mineral input from floods											x			x	x				x			
Creation of spoil banks															x	x			x			
Increased bank erosion																		x				
Increased beach erosion														x								
Loss of groundwater		x						x			x								x			
Lowered water table		x	x					x			x							x	x		x	
Reduction of spring flow		x						x														

(from Darnell et al. 1976)

Appendix

Table A-9. The primary physical and chemical effects of various types of construction activities on the riparian and wetland environments of the United States.

Construction activity / Physical and chemical effects									Dam construction								Dredging & spoil placement					
	Preconstruction activities	Impervious surfacing & earthwork	Drainage ditching	Building construction	Open air industrial plant constr'n.	Drainage structures	Tunnel construction	Mineral extraction on land	General effects	Upstream effects	Near downstream eff.	Far downstream eff.	Estuarine effects	Marine effects	Fill construction	Bridging	Gen. & immed. effects	Channelization effects	Riparian effects	Bay & estuarine eff.	Marshland effects	Waterway margin constr.
WETLAND ENVIRONMENT - Circulation																						
Loss of wetland habitat	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x	x
Reduction of habitat diversity		x						x	x								x	x				
Jeopardization of certain habitat types								x	x									x				
Modification of normal seasonal flow patterns								x	x	x	x	x	x									
Drastic fluctuation in water levels		x	x	x				x			x	x										
Drastic fluctuation in flow rates		x	x	x				x			x	x										
Increased peak flows		x						x														
Reduced minimal flows		x						x		x												
Elimination of peak flows											x	x										
Reduction in flow volume									x		x	x	x	x								
General increase in flow rate																		x				
Modification of internal circulation patterns													x				x			x		
Increased downstream flooding		x	x					x	x			x						x				

(from Darnell et al. 1976)

Appendix
Table A-11 The primary physical and chemical effects of various types of construction activities on the riparian and wetland environments of the United States.

Construction activity / Physical and chemical effects									Dam construction								Dredging & spoil placement					
	Preconstruction activities	Impervious surfacing & earthwork	Drainage ditching	Building construction	Open air industrial plant constr'n.	Drainage structures	Tunnel construction	Mineral extraction on land	General effects	Upstream effects	Near downstream eff.	Far downstream eff.	Estuarine effects	Marine effects	Fill construction	Bridging	Gen. & immed. effects	Channelization effects	Riparian effects	Bay & estuarine eff.	Marshland effects	Waterway margin constr.
WETLAND ENVIRONMENT - Sediment																						
Shortening of stream		x	x			x												x				
Deepening of channel																		x				
Increase in stream gradient																		x				
Increase in bottom scouring		x						x														x
Widening of channel																		x				
Reduction of sediment flushing											x	x	x									
Reduction of sediment and nutrient input												x	x	x	x							
Reduction of leaf litter wash into streams											x								x			
Creation of canals in swamps and marshes															x	x	x	x	x		x	
Increase in turbidity	x	x	x	x	x	x	x	x			x						x	x		x		
Increase in sedimentation	x	x	x	x	x	x	x	x		x	x						x	x		x	x	
Clogging of stream riffles		x						x		x	x						x	x				
Filling of pool areas		x						x		x	x	x										
Reduction of particle size of surface sediments																				x		
Altered bottom topography		x						x	x	x	x	x	x				x	x		x		

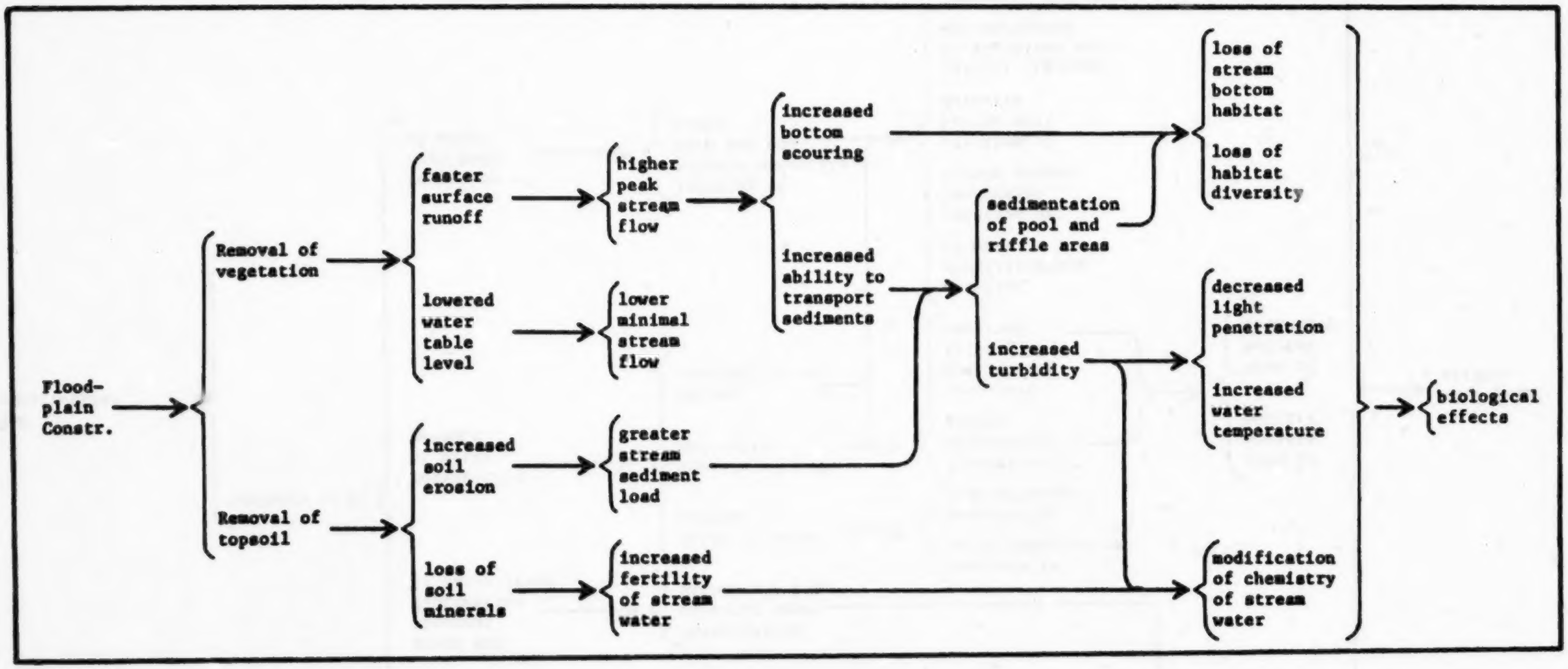
(from Darnell et al. 1976)

Appendix

Table A-12. The primary physical and chemical effects of various types of construction activities on the riparian and wetland environments of the United States.

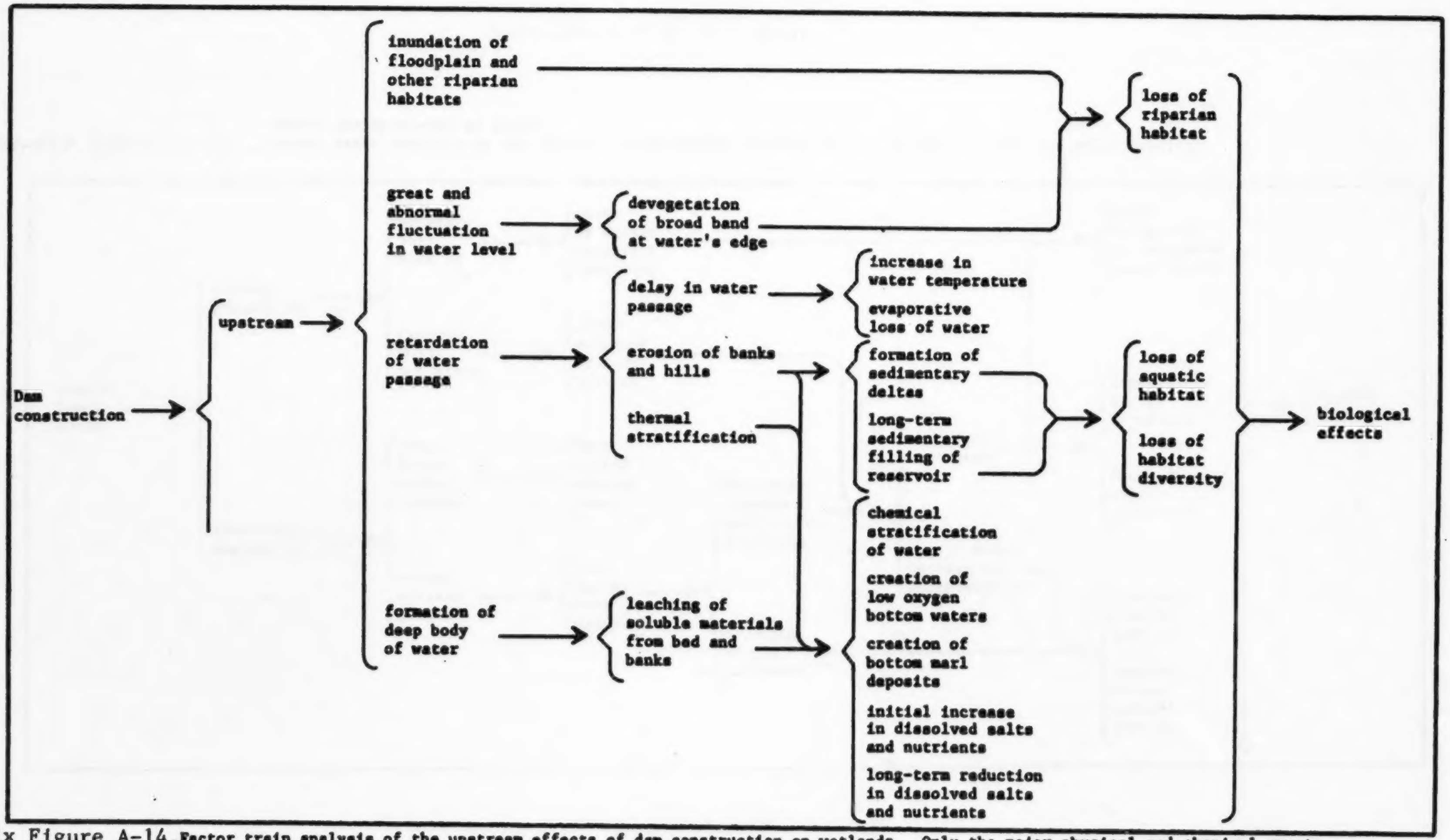
Construction activity / Physical and chemical effects	Preconstruction activities	Impervious surfacing & earthwork	Drainage ditching	Building construction	Open air industrial plant constr'n.	Drainage structures	Tunnel construction	Mineral extraction on land	Dam construction						Fill construction	Bridging	Dredging & spoil placement					Waterway margin constr.
									General effects	Upstream effects	Near downstream eff.	Far downstream eff.	Estuarine effects	Marine effects			Gen. & immed. effects	Channelization effects	Riparian effects	Bay & estuarine eff.	Marshland effects	
WETLAND ENVIRONMENT - Chem. & Phys. Properties																						
Reduction in light penetration		x						x		x							x	x				
Elevation of temperature		x						x		x	x	x	x				x					
Modification (gen. lowering) of pH		x						x		x	x											
Modification of natural chemical composition		x	x	x	x	x		x	x	x	x									x	x	x
Increased oxygen demand		x	x	x	x	x		x		x	x						x	x		x	x	
Supersaturation with nitrogen gas											x											
Addition of chemical pollutants		x	x	x	x	x		x			x						x			x		x
Build-up of bottom-associated pollutants		x	x	x	x	x		x					x						x	x		
Reduction of freshwater input													x							x	x	
Increase in salinity												x	x		x				x	x	x	
Sharpening of salinity gradients													x							x	x	

(from Darnell et al. 1976)


Flood-plain Constr.
Removal of vegetation
Removal of topsoil
faster surface runoff
lowered water table level
increased soil erosion
loss of soil minerals
higher peak stream flow
lower minimal stream flow
greater stream sediment load
increased fertility of stream water
increased bottom scouring
increased ability to transport sediments
sedimentation of pool and riffle areas
increased turbidity
loss of stream bottom habitat
loss of habitat diversity
decreased light penetration
increased water temperature
modification of chemistry of stream water
biological effects

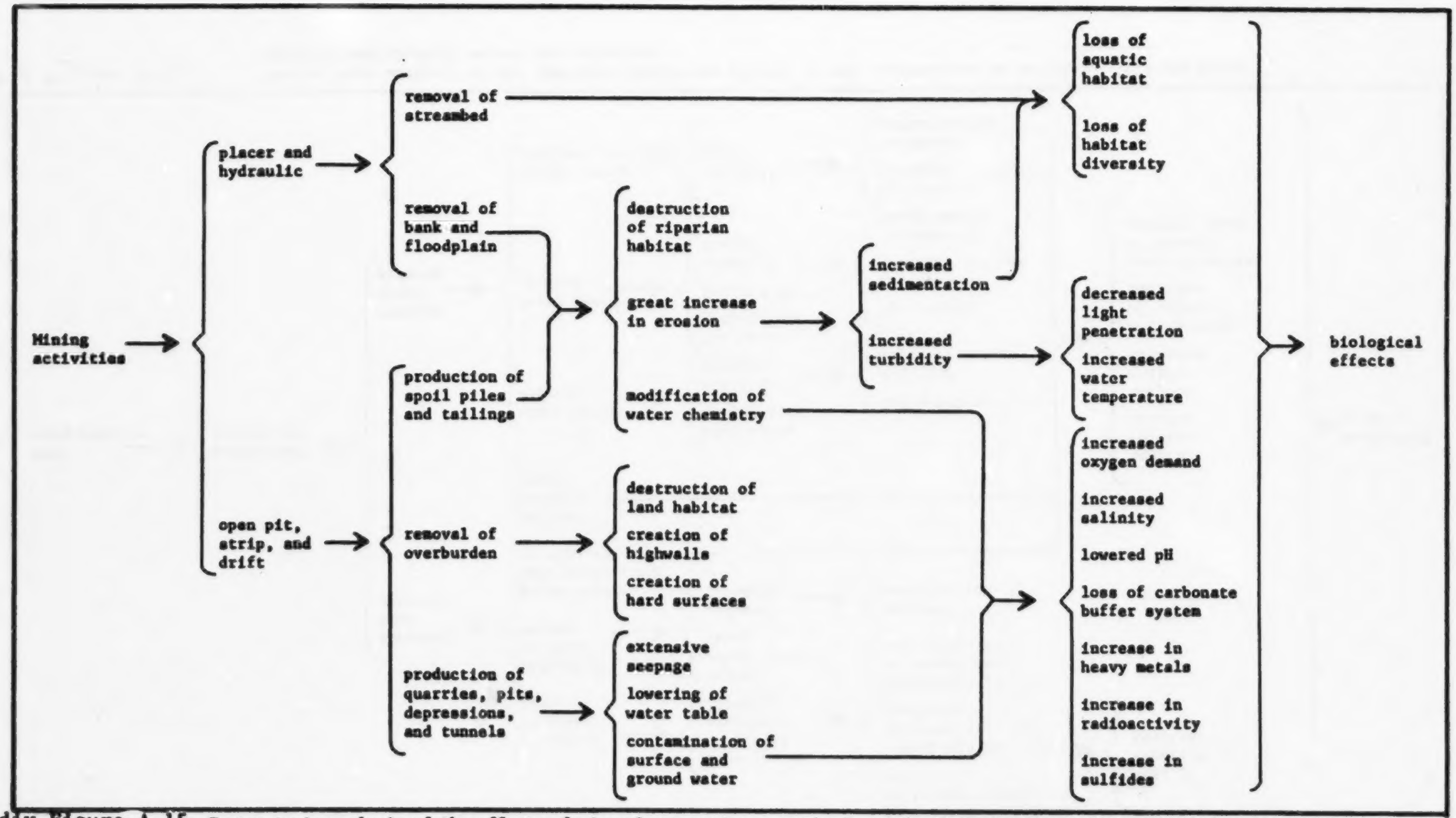
Appendix Figure A-13. Factor train analysis of the effects of floodplain construction on wetlands. Only the major physical events are presented in detail.

(from Darnell et al. 1976)


Dam construction
upstream
inundation of floodplain and other riparian habitats
great and abnormal fluctuation in water level
retardation of water passage
formation of deep body of water
devegetation of broad band at water's edge
delay in water passage
erosion of banks and hills
thermal stratification
leaching of soluble materials from bed and banks
increase in water temperature
evaporative loss of water
formation of sedimentary deltas
long-term sedimentary filling of reservoir
chemical stratification of water
creation of low oxygen bottom waters
creation of bottom marl deposits
initial increase in dissolved salts and nutrients
long-term reduction in dissolved salts and nutrients
loss of riparian habitat
loss of aquatic habitat
loss of habitat diversity
biological effects

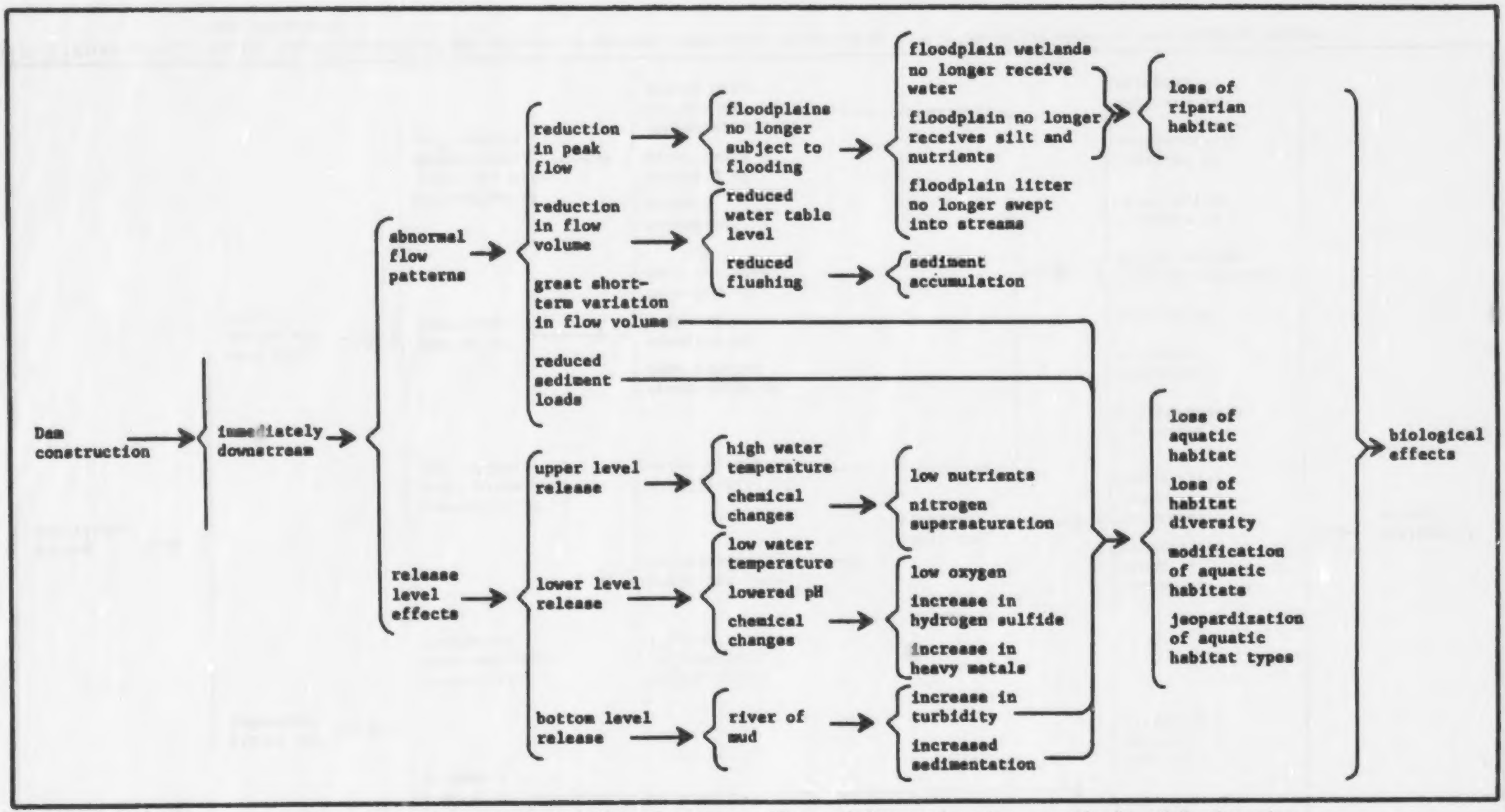
Appendix Figure A-14. Factor train analysis of the upstream effects of dam construction on wetlands. Only the major physical and chemical events are presented.

(from Darnell et al. 1976)


Mining activities
placer and hydraulic
open pit, strip, and drift
removal of streambed
removal of bank and floodplain
production of spoil piles and tailings
removal of overburden
production of quarries, pits, depressions, and tunnels
destruction of riparian habitat
great increase in erosion
modification of water chemistry
destruction of land habitat
creation of highwalls
creation of hard surfaces
extensive seepage
lowering of water table
contamination of surface and ground water
increased sedimentation
increased turbidity
loss of aquatic habitat
loss of habitat diversity
decreased light penetration
increased water temperature
increased oxygen demand
increased salinity
lowered pH
loss of carbonate buffer system
increase in heavy metals
increase in radioactivity
increase in sulfides
biological effects

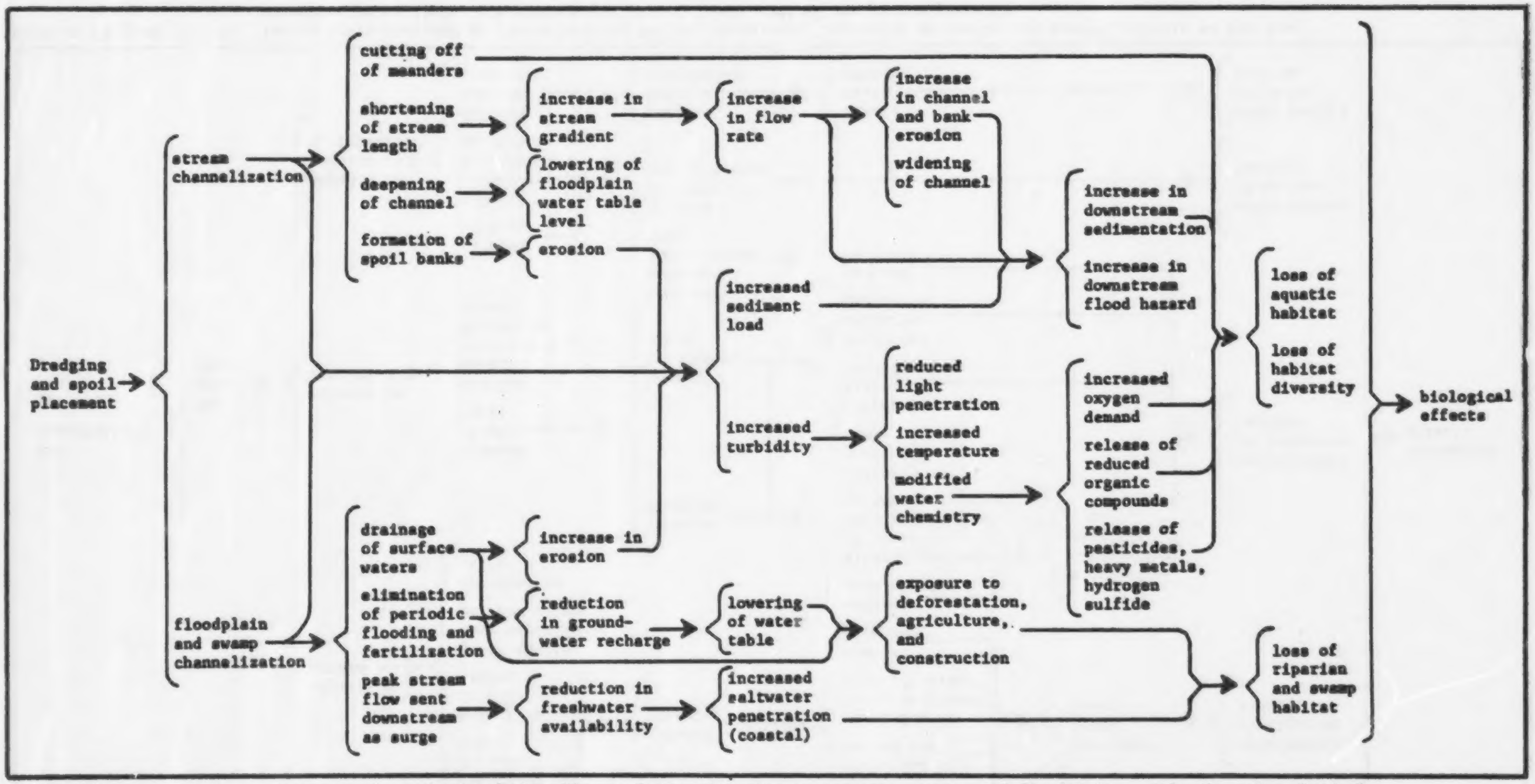
Appendix Figure A-15. Factor train analysis of the effects of mineral extraction on wetlands. Only the major physical and chemical events are presented.

(from Darnell et al. 1976)



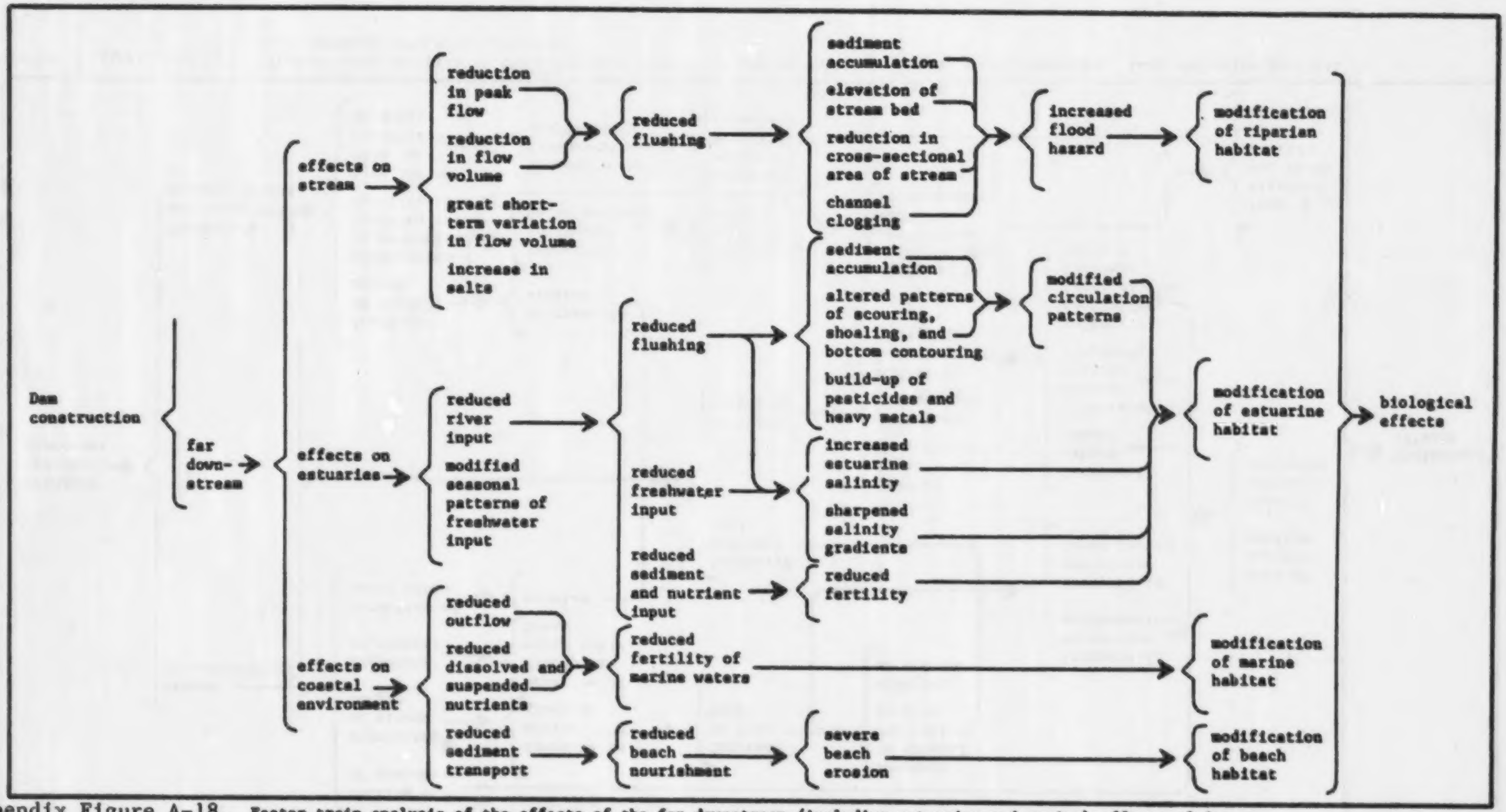
Appendix Figure A-16. Factor train analysis of the immediate downstream effects of dam construction on wetlands. Only the major physical and chemical events are presented.

(from Darnell *et al*. 1976)


Dredging and spoil placement
stream channelization
floodplain and swamp channelization
cutting off of meanders
shortening of stream length
deepening of channel
formation of spoil banks
drainage of surface waters
elimination of periodic flooding and fertilization
peak stream flow sent downstream as surge
increase in stream gradient
lowering of floodplain water table level
erosion
increase in erosion
reduction in ground-water recharge
reduction in freshwater availability
increase in flow rate
increased sediment load
increased turbidity
lowering of water table
increased saltwater penetration (coastal)
increase in channel and bank erosion
widening of channel
reduced light penetration
increased temperature
modified water chemistry
exposure to deforestation, agriculture, and construction
increase in downstream sedimentation
increase in downstream flood hazard
increased oxygen demand
release of reduced organic compounds
release of pesticides, heavy metals, hydrogen sulfide
loss of aquatic habitat
loss of habitat diversity
loss of riparian and swamp habitat
biological effects

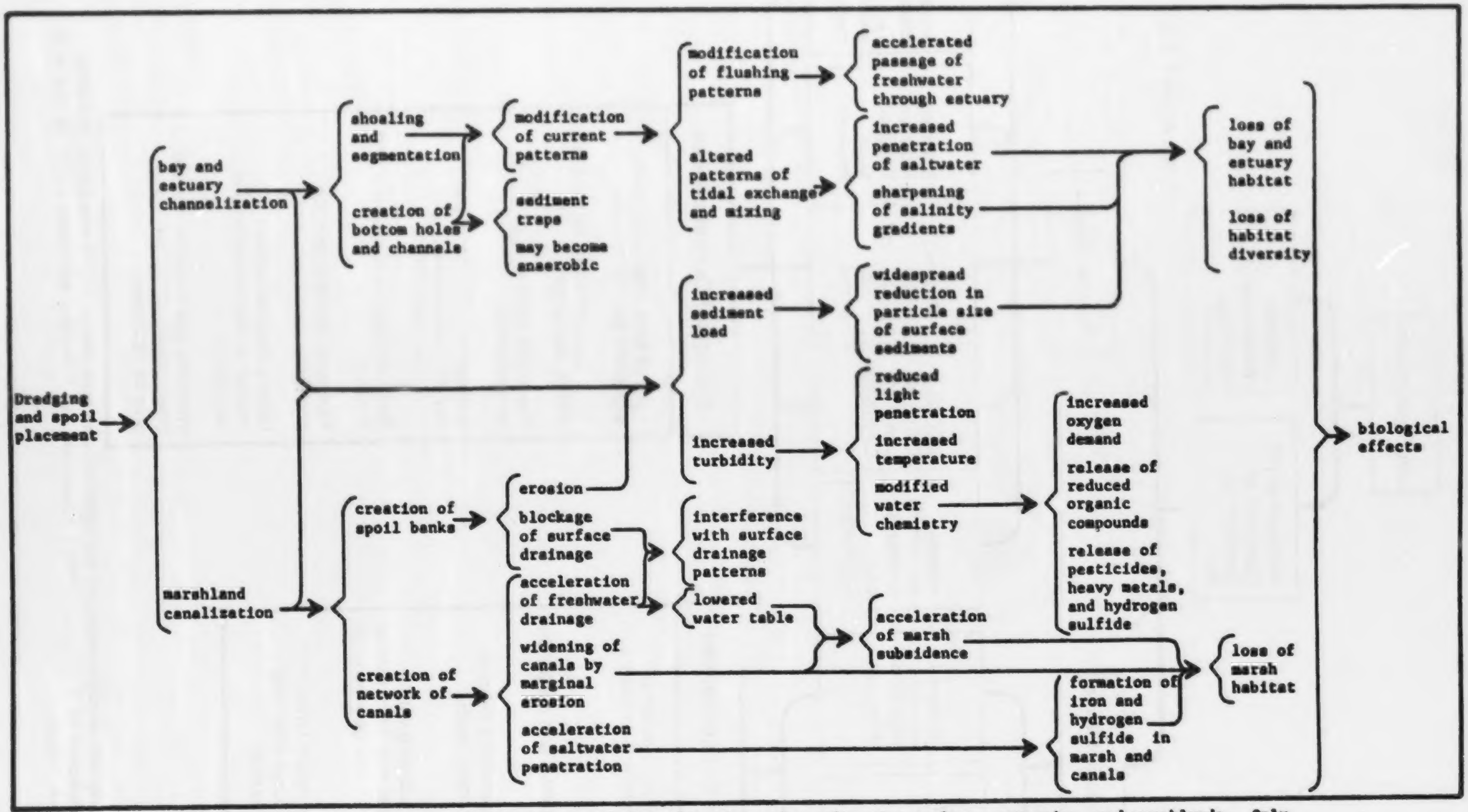
Appendix Figure A-17. Factor train analysis of the effects of channelization on streams, swamps, and floodplains. Only the major physical and chemical events are presented.

(from Darnell *et al*. 1976)


Dam construction
far down-stream
effects on stream
reduction in peak flow
reduction in flow volume
great short-term variation in flow volume
increase in salts
reduced flushing
sediment accumulation
elevation of stream bed
reduction in cross-sectional area of stream
channel clogging
increased flood hazard
modification of riparian habitat
effects on estuaries
reduced river input
modified seasonal patterns of freshwater input
reduced flushing
reduced freshwater input
reduced sediment and nutrient input
sediment accumulation
altered patterns of scouring, shoaling, and bottom contouring
build-up of pesticides and heavy metals
increased estuarine salinity
sharpened salinity gradients
reduced fertility
modified circulation patterns
modification of estuarine habitat
biological effects
effects on coastal environment
reduced outflow
reduced dissolved and suspended nutrients
reduced sediment transport
reduced fertility of marine waters
reduced beach nourishment
severe beach erosion
modification of marine habitat
modification of beach habitat

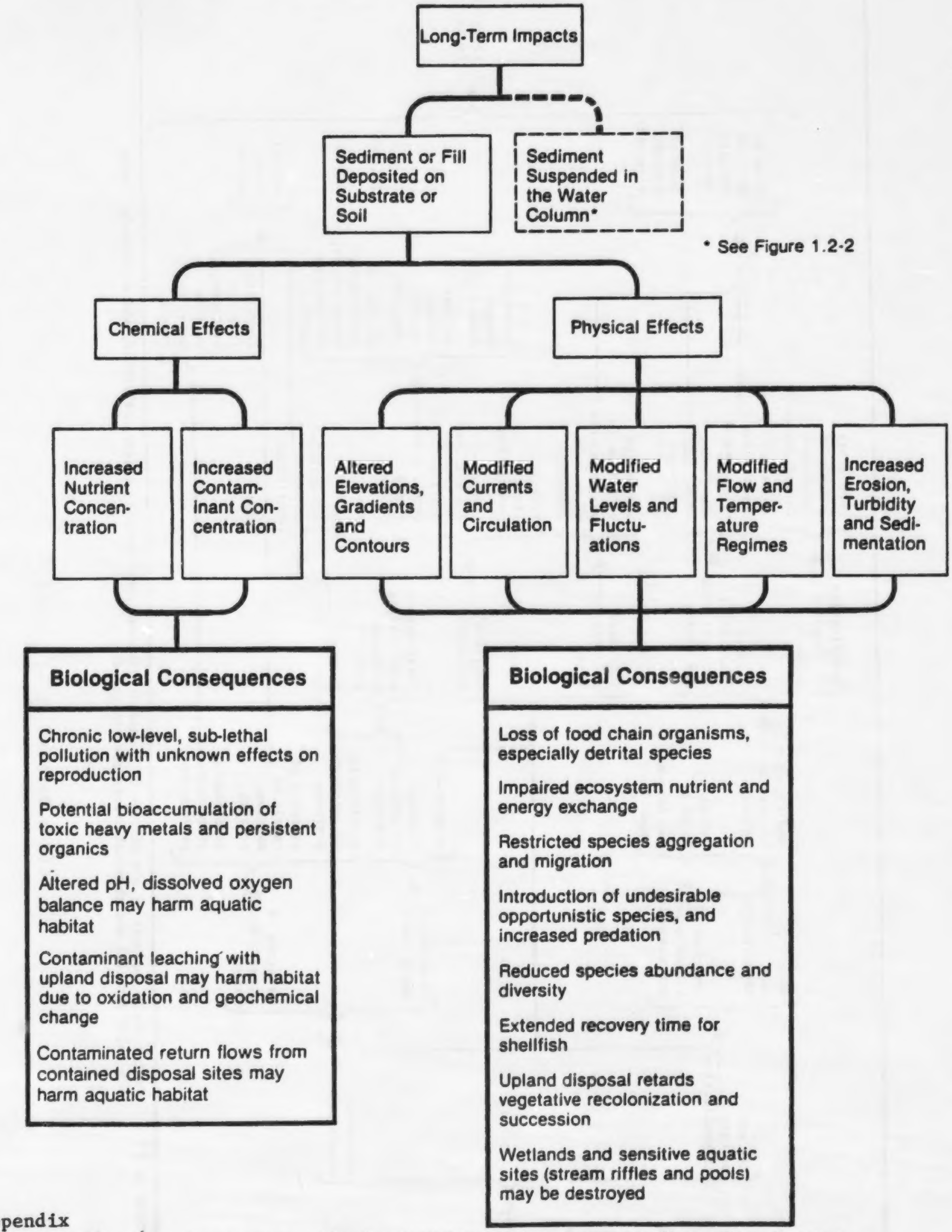
Appendix Figure A-18. Factor train analysis of the effects of the far downstream (including estuarine and marine) effects of dam construction on wetlands. Only the major physical and chemical events are presented.

(from Darnell et al, 1976)


Dredging and spoil placement
bay and estuary channelization
marshland canalization
shoaling and segmentation
creation of bottom holes and channels
creation of spoil banks
creation of network of canals
modification of current patterns
sediment traps
may become anaerobic
erosion
blockage of surface drainage
acceleration of freshwater drainage
widening of canals by marginal erosion
acceleration of saltwater penetration
modification of flushing patterns
altered patterns of tidal exchange and mixing
increased sediment load
increased turbidity
interference with surface drainage patterns
lowered water table
accelerated passage of freshwater through estuary
increased penetration of saltwater
sharpening of salinity gradients
widespread reduction in particle size of surface sediments
reduced light penetration
increased temperature
modified water chemistry
acceleration of marsh subsidence
increased oxygen demand
release of reduced organic compounds
release of pesticides, heavy metals, and hydrogen sulfide
formation of iron and hydrogen sulfide in marsh and canals
loss of bay and estuary habitat
loss of habitat diversity
loss of marsh habitat
biological effects

Appendix Figure A-19. Factor train analysis of the effects of channelization and canalization on bays, estuaries, and marshlands. Only the major physical and chemical events are presented.

(from Darnell et al. 1976).


Long-Term Impacts
Sediment or Fill Deposited on Substrate or Soil
Sediment Suspended in the Water Column*
* See Figure 1.2-2
Chemical Effects
Physical Effects
Increased Nutrient Concentration
Increased Contaminant Concentration
Altered Elevations, Gradients and Contours
Modified Currents and Circulation
Modified Water Levels and Fluctuations
Modified Flow and Temperature Regimes
Increased Erosion, Turbidity and Sedimentation
Biological Consequences
Biological Consequences

Chronic low-level, sub-lethal pollution with unknown effects on reproduction

Potential bioaccumulation of toxic heavy metals and persistent organics

Altered pH, dissolved oxygen balance may harm aquatic habitat

Contaminant leaching with upland disposal may harm habitat due to oxidation and geochemical change

Contaminated return flows from contained disposal sites may harm aquatic habitat

Loss of food chain organisms, especially detrital species

Impaired ecosystem nutrient and energy exchange

Restricted species aggregation and migration

Introduction of undesirable opportunistic species, and increased predation

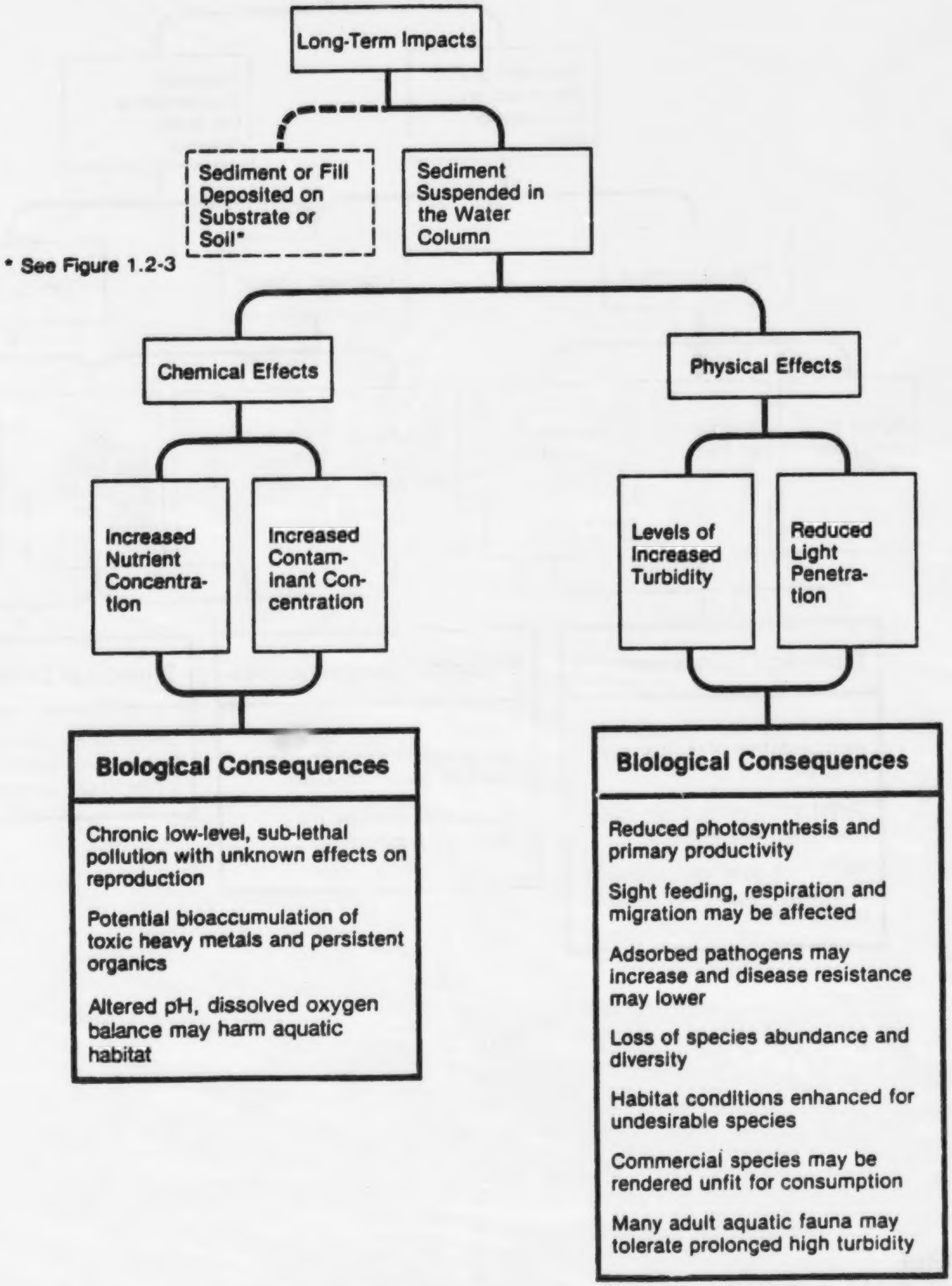
Reduced species abundance and diversity

Extended recovery time for shellfish

Upland disposal retards vegetative recolonization and succession

Wetlands and sensitive aquatic sites (stream riffles and pools) may be destroyed

Appendix
Figure A-20. long-term environmental and ecological impacts from dredge and fill operations: Substrate and soil effects (adapted by R. Wayne Nelson & Associates, Inc. from Allen and Hardy 1980; Saucier *et al.* 1978; and USEPA, 1980).


Long-Term Impacts
Sediment or Fill Deposited on Substrate or Soil*
Sediment Suspended in the Water Column
* See Figure 1.2-3
Chemical Effects
Physical Effects
Increased Nutrient Concentration
Increased Contaminant Concentration
Levels of Increased Turbidity
Reduced Light Penetration
Biological Consequences
Biological Consequences

Biological Consequences

Chronic low-level, sub-lethal pollution with unknown effects on reproduction

Potential bioaccumulation of toxic heavy metals and persistent organics

Altered pH, dissolved oxygen balance may harm aquatic habitat

Biological Consequences

Reduced photosynthesis and primary productivity

Sight feeding, respiration and migration may be affected

Adsorbed pathogens may increase and disease resistance may lower

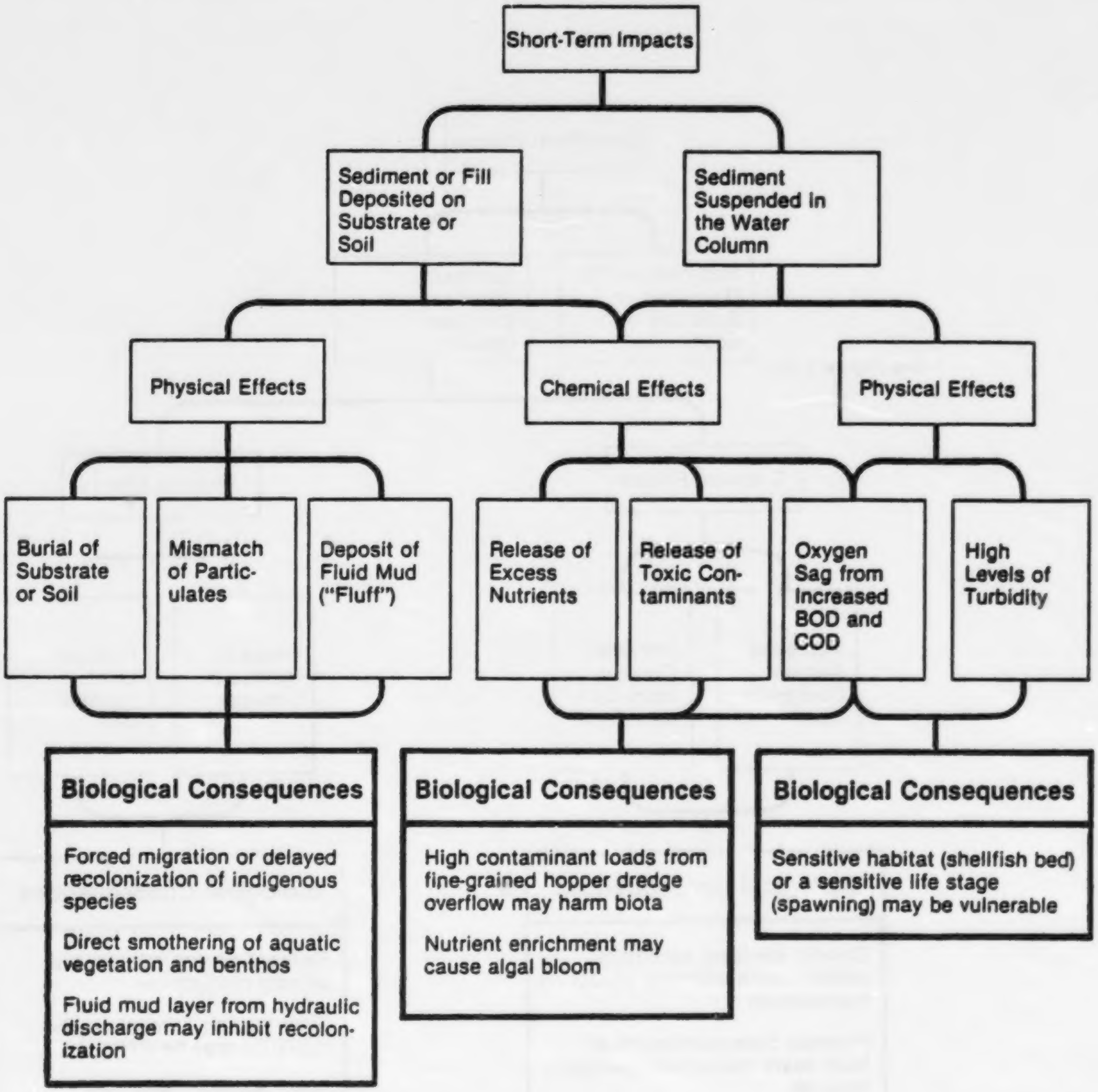
Loss of species abundance and diversity

Habitat conditions enhanced for undesirable species

Commercial species may be rendered unfit for consumption

Many adult aquatic fauna may tolerate prolonged high turbidity

Appendix
Figure A-21. Long-term environmental impacts from dredge and fill operations: Water column effects (adapted by R. Wayne Nelson & Associates, Inc. from Allen and Hardy 1980: Saucier *et al.* and USEPA 1980).


Short-Term Impacts
Sediment or Fill Deposited on Substrate or Soil
Sediment Suspended in the Water Column
Physical Effects
Chemical Effects
Physical Effects
Burial of Substrate or Soil
Mismatch of Particulates
Deposit of Fluid Mud ("Fluff")
Release of Excess Nutrients
Release of Toxic Contaminants
Oxygen Sag from Increased BOD and COD
High Levels of Turbidity
Biological Consequences
Forced migration or delayed recolonization of indigenous species
Direct smothering of aquatic vegetation and benthos
Fluid mud layer from hydraulic discharge may inhibit recolonization
Biological Consequences
High contaminant loads from fine-grained hopper dredge overflow may harm biota
Nutrient enrichment may cause algal bloom
Biological Consequences
Sensitive habitat (shellfish bed) or a sensitive life stage (spawning) may be vulnerable

Appendix
Figure A-22. Short-term environmental and ecological impacts from dredge and fill operations: Water column, substrate and soil effects (adapted by R. Wayne Nelson & Associates, Inc. from Allen and Hardy 1980; Saucier *et al.* 1978; and USEPA 1980).

APPENDIX B

Summary Tables
From WRC Study
(Lonard *et al*. 1981)

Table 1

Summary of Critical Elements to be Measured for an Assessment of Functional Values for 20 Wetland Evaluation Procedures

Methodology Number	Citation	Habitat*	Hydrology**	Recreation†	Agriculture/Silviculture††	Heritage
1	Brown, A., et al. 1974	Classification of prime and nonprime wetlands, life forms and sublife forms, classification according to use by man, wetland habitat classes and subclasses, size classes, wetland site types, surrounding habitat types, wetland cover types, wetland interspersion, wetland juxtaposition	NA	NA	NA	NA
2	Dee, N., et al. 1973	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	NA	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured
3	Fried, E. 1974	(1) Biological productivity: total alkalinity, area with 6"-24" water depth, adjacent soil fertility, Soil Conservation Service Wildlife Suitability rating, vegetative interspersion, number of vegetative classes, plant species, fish and wildlife species, (2) vulnerability rating, and (3) additional factors	NA	NA	NA	NA
4	Galloway, G. E. 1978	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	NA	NA	Interdisciplinary team must decide critical elements to be measured

(Continued)

Note: NA. Not addressed.

* Habitat. Habitat functions include the related categories of common wetland plant and animal species, endangered, threatened, or rare plant and animal species, game species, commercial species, and nongame species.

** Hydrology. Hydrology functions include floodwater storage, shoreline protection, ground and surface water recharge and discharge, and water quality.

† Recreation. Recreation functions include water-required activities such as boating, sport fishing, photography, nature study, camping, etc.

†† Agriculture/Silviculture. These functions include harvestable products of wetlands such as cultivated crops, pastureland and hay crops, lumber, peat, etc.

Heritage Heritage functions include scenic, cultural, scientific, visual, and aesthetic values of wetlands.

(Sheet 1 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
5	Golet, F. C. 1973	Wetland class richness, dominant wetland class, size category, subclass richness, site type, surrounding habitat type, cover types, vegetative interspersion, wetland juxtaposition, water chemistry	NA	NA	NA	NA
6	Gupta, T. R., and Foster, J. H. 1973	NA	NA	NA	NA	Scenic values: land form contrast, land form diversity, land use contrast, wetland type diversity, wetland size, water body size
7	Kibby, H. V. 1978	NA	Water quality: frequency of hydrologic periodicity, estimation of net primary productivity	NA	NA	NA
8	Larson, J. S., ed. 1976	Wetland class richness, dominant wetland class, size category, subclass richness, site type, cover types, vegetative interspersion, wetland juxtaposition	Presence of a useful water supply: base flow, test borings, surficial geology, ground water potentiometric map, drilling, and pumping sites	NA	NA	Land form contrast, land form diversity, wetland-edge complexity, associated water body size, diversity of associated water bodies surrounding land use contrast, surrounding land use diversity, wetland type diversity, internal wetland contrast, wetland size
9	Reppert, R. T., et al. 1979	Productivity and food chain relations: net primary productivity, mode of detrital transport, food chain support, determination of key game, commerical, aesthetic species	Hydrologic periodicity, shoreline protection (vegetation, width, fetch, cultural development), flood water storage (vegetative cover), natural groundwater storage (soil depth, porosity, transmissivity, etc), water quality improvement (type of wetland, areal and waste loading relationships), geographical and locational factors	Investigator's professional judgment	Investigator's professional judgment	Investigator's professional judgment

(Continued)

(Sheet 2 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
10	Schuldiner, P. W., et al. 1979	Potential biological impacts on wetlands: change in wetland size, change in species composition, change in class composition, change in primary productivity and secondary productivity, sudden mortality of aquatic species, barrier to animal movements, encouragement of beaver activity, rare and endangered species	Potential impacts on physical properties: (1) Impacts associated with surface flows (change in mean water level, change in periodicity, change in wetland circulatory patterns), (2) Impacts associated with subsurface flows (alteration of local water table levels), (3) Impacts associated with creation of channels (drainage of surface waters, periodic flooding, and fertilization change in retention storage), (4) Impacts associated with tidal flows (damping of tidal variations, alteration of salinity patterns), (5) Impacts associated with water quality (turbidity, sedimentation, chemical pollution, temperature patterns)	NA	NA	NA

(Continued)

(Sheet 3 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	NA	(1) Water quality improvement (vegetation types, wetland size, water residence time and velocity, hydraulic loading, wetland location), (2) Groundwater recharge (soils, wetland size, evapotranspiration rate, vegetation, wet/dry cycles, presence of a multi-aquifer system, water quality, retention time), (3) Storm and flood water storage (area soils and water table, vegetation, roughness, topography), (4) Shoreline protection (extent and type of vegetation, soils, frequency of inundation, location and elevation of wetland, fetch, bottom roughness, cultural developement)	NA	NA	NA
12	Smardon, R. C. 1972	NA	NA	Recreational carrying capacity, recreational diversity	NA	Visual-cultural values: land form contrast, land form diversity, wetland edge complexity, associated water body size, diversity of associated water bodies, surrounding land use contrast and diversity, wetland type diversity, internal wetland contrast, wetland size, multiple cultural attributes
13	Solomon, R. C., et al. 1977	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	Interdisciplinary team must decide critical elements to be measured	NA	Interdisciplinary team must decide critical elements to be measured

(Continued)

(Sheet 4 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
14	State of Maryland, Dept of Natural Resources. Undated	Net primary production, wildlife food value, vegetation/water interspersion variable, vegetation form vegetation interspersion	NA	NA	NA	NA
15	U. S. Army Engineer Division, Lower Miss. Valley (NES). 1980	A. Aquatic ecosystem evaluation 1. Streams: sinuosity, fish species associations, turbidity, total dissolved solids, chemical type, benthic diversity. 2. Lakes/lentic habitats: mean depth, turbidity, total dissolved solids, chemical type, shoreline development, spring flooding, fish standing crop B. Terrestrial ecosystem evaluation 1. Wooded swamps - bottomland hardwoods: species association, percent overstory, percent area inundated, ground cover - understory coverage, mast proximity, tract size, number of trees more than 16 in. DBH, number of snags. 2. Terrestrial wildlife value of aquatic habitats: cover by aquatic plants distance to disturbance, water depth in August, distance to river, brush cover, flooding frequency, winter overflow, distance from woods, size of water body, and shallow water. Also evaluates seasonally overflowed bottomland hardwoods	NA	NA	NA	NA

(Continued)

(Sheet 5 of 7)

Table 1 (Continued)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
16	U. S. Army Engineer Division, New England. 1972	Interdisciplinary team must decide critical elements to be measured; detailed analysis of wildlife in the watershed project area	Flood water storage: basic hydrologic analyses for determining storage contained in lakes and wetlands of watershed. Flow duration frequency, storage yield, dependability, peak discharge frequencies, past flood analysis	Estimated annual user days for various activities, inventory of recreation site supply, and analysis of activities and demands in the watershed	Interdisciplinary team must decide critical elements to be measured; detailed analysis required for present and projected activities in watershed	Interdisciplinary team must decide critical elements to be measured; detailed analysis required
17	U. S. Department of Agriculture. 1978	Fish habitat: principle wetland type, size, location of wetland, presence of fish cover, presence of game fish. Wetland wildlife habitat: principle wetland type, number of wetland types, diversity of adjacent land use, percent of perimeter with 300' wide buffer strip, size, islands	Flood control: (estimations) effective storage of wetland on total watershed above, effective storage of upstream reservoirs and wetlands on total watershed, effective storage on main stem between wetland and potential damage area or major confluence, distance downstream to potential damage area, severity of potential flood damage	Boating: principal wetland type used for boating, acreage, physical access, boatable stream present. Fishing: principal wetland type, wetland size, physical access. Nature study: diversity of plants and animals, percent of urban development within 300 ft of wetland perimeter. Hunting: waterfowl hunting, access for hunting	Forest management, percent public ownership of forest in wetland, stand size, portion of forest land with 81-100 percent crown closure, portion of wetland forested, predominant forest cover type, shape of forested wetland, type of soil, accessibility	Uniqueness: location, endangered species habitat, regionally rare plant community, migratory birds, size, archaeological, geological, or historical significance. Visual quality: number of public roads, overlooks accessible by path, deciduous woodland type, topography, islands, appearance and condition, wetland types
18	U. S. Fish and Wildlife (HEP). 1980	1. Determine applicability of HEP. 2. Define study limits. 3. Determine baseline habitat units. a. Definition of study area. b. Delineation of cover types. c. Selection of evaluation species. 4. Compare baseline areas. 5. Determination of future habitat units. 6. Comparison of proposed actions	NA	NA	NA	NA

(Continued)

(Sheet 6 of 7)

Table 1 (Concluded)

Methodology Number	Citation	Habitat	Hydrology	Recreation	Agriculture/Silviculture	Heritage
19	Virginia Institute of Marine Science. Undated	Vegetative production, wildlife food value, diversity of plant species, percent of marsh flooded daily, relative length of marsh-water interface	NA	NA	NA	NA
20	Winchester, B. H. and Harris, L. D. 1979	Determination of wetland size, wetland contiguity, vegetative structural diversity, and the type and amount of edge relative to wetland size	Determination of wetland size, wetland configuration, wetland contiguity, edge area relationships	NA	NA	NA

Table 2

Summary of the Geographic Features of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Inland*	Coastal**	Regional Application†	Widespread Application††	Use
1	Brown, A., et al. 1974	Yes; a variety of inland wetland types	NA	Developed for wetlands in Arkansas	Must be modified for widespread application	Can be used to assess a single wetland site. Can be used to rank similar or dissimilar wetland types
2	Dee, N., et al. 1973	Used for water resource development projects on rivers or river systems; could be modified for wetlands	NA	Applicable	Applicable	More useful for an assessment of a single wetland area
3	Fried, E. 1974	Applicable to freshwater wetlands and wetland restoration projects	Developed for tidal wetlands but has not been used for that purpose	Developed for wetland acquisition studies in New York	Must be modified for use in other regions	More useful for ranking wetlands
4	Galloway, G. E. 1978	Applicable to a variety of wetland types	Applicable to coastal wetlands and estuaries	Applicable	Applicable	Applicable for use in inland and coastal areas
5	Golet, F. C. 1973	Applicable to a variety of wetland types	NA	Developed for Mass. and useful in the general region	Applicable but must be modified for use outside the NE	Applicable for use in inland and coastal areas
6	Gupta, T. R., and Foster, J. H. 1973	Applicable	NA	Developed for Mass. and useful in the general region	Applicable but must be modified for use outside the NE	Applicable for use in inland and coastal areas
7	Kibby, H. V. 1978	Applicable to wetlands adjacent to rivers	NA	Applicable	Applicable	More useful for a narrative evaluation of a single wetland site

(Continued)

Note: NA. Not addressed.
* Can the procedure be used to evaluate a variety of inland wetland types?
** Can the procedure be used to evaluate a variety of coastal wetland types?
† Was the procedure developed for regional use?
†† Was the procedure developed for widespread application?

(Sheet 1 of 3)

Table 2 (Continued)

Methodology Number	Citation	Inland	Coastal	Regional Application	Widespread Application	Use
8	Larson, J. S., ed. 1976	Applicable	NA	Developed for Mass. and useful in the general region	Applicable but must be modified for use outside the NE	Applicable for both requirements; comparison of wetlands in same general region
9	Reppert, R. T., et al. 1979	Applicable	Applicable	Applicable	Applicable	Applicable for use in inland and coastal areas
10	Schuldiner, P., et al. 1979	Applicable	Applicable	Applicable	Applicable	Applicable for an assessment of a single wetland
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Applicable	Applicable	Applicable	Applicable	Applicable for use in inland and coastal areas
12	Smardon, R. C. 1972	Applicable	NA	Developed for Mass. and useful in the general region	Applicable but must be modified for use outside the NE	Applicable for use in inland and coastal areas
13	Solomon, R. C., et al. 1977	Applicable, but developed for Water Resources projects	Possibly applicable, but developed for Water Resources projects	Applicable	Applicable	Applicable for use in inland and coastal areas
14	State of Maryland, Dept of Natural Resources. Undated	NA	Applicable	Developed for Maryland and useful in the general region	Must be modified for use in coastal zones outside the region	Applicable for both requirements, but comparisons must be made of wetlands in the same salinity regime
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	Applicable, but developed for Water Resourced planning projects	NA, but salt marshes will be evaluated in future revision of procedure	Ecosystems in the Lower Mississippi River Valley	Can be modified for use in other regions	Developed to be used in comparing project impacts or alternatives on existing and future "without"

(Continued)

(Sheet 2 of 3)

Table 2 (Concluded)

Methodology Number	Citation	Inland	Coastal	Regional Application	Widespread Application	Use
16	U. S. Army Engineer Division, New England. 1972	Applicable, but unique to eastern Mass.	NA	Applicable for specific study site in eastern Mass.	NA	Not easily modified to assess and rank several wetlands
17	U. S. Department of Agriculture. 1978	Applicable	Applicable	Developed for Mass. and useful in general region	Can be modified for use in other regions	Applicable for use in inland and coastal areas
18	U. S. Fish and Wildlife Service. 1980 1980	Developed for inland terrestrial and aquatic habitats	Not extensively applied to estuarine systems, but concepts may be applicable	Applicable	Applicable	Useful for evaluating baseline conditions and impacts in a single wetland. Also designed to rank habitats as to their wildlife values
19	Virginia Institute of Marine Science. Undated	NA	Applicable to tidal wetlands	Developed for tidal wetlands in Virginia	May be difficult to modify for use in other coastal regions	Applicable for use in inland and coastal areas
20	Winchester, B. H., and Harris, L. D. 1979	Applicable	NA	Developed for freshwater wetlands in Florida	Could be modified and used in noncoastal wetlands of the southeastern coastal plain	Applicable for use in noncoastal wetlands

(Sheet 3 of 3)

Table 3

Summary of Salient Features of 20 Evaluation Procedures for Personnel Needs

Methodology Number	Citation	Resource Manager*	Interdisciplinary Team**	Implications Relative to User Needs
1	Brown, A., et al. 1974	Yes	No	Experts should be consulted concerning specific problems
2	Dee, N., et al. 1973	No	Yes	The composition of the interdisciplinary team is dependent upon the nature of the Water Resources project but will include biologists, social scientists, and physical scientists
3	Fried, E. 1974	Yes	No	Technical assistance from plant and animal ecologists would facilitate the acquisition of habitat-related data
4	Galloway, G. E. 1978	No	Yes	Minimum requirements for an interdisciplinary team include an ecologist, botanist, zoologist, hydrogeologist, and a social scientist. In addition, the procedure requires a panel of laymen. Computer facilities are required
5	Golet, F. C. 1973	Yes	No	The resource manager should have a good background in wildlife biology, ecology, and plant systematics

(Continued)

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* Does the procedure require a resource manager for decisionmaking?

** Does the procedure require an interdisciplinary team for decisionmaking?

(Sheet 1 of 4)

Table 3 (Continued)

Methodology Number	Citation	Resource Manager	Interdisciplinary Team	Implications Relative to User Needs
6	Gupta, T. R., and Foster, J. H. 1973	Yes	No	Scenic values of wetlands could be evaluated fairly rapidly by a resource manager without requiring special training in the use of the procedure
7	Kibby, H. V. 1978	Yes	No	A technician would be helpful if field estimation of net primary productivity is required. A resource manager could make general evaluations of water quality without a specialized training requirement
8	Larson, J. S., ed. 1976	Yes	Yes, under certain conditions	A resource manager who can read maps and use stereo-aerial photographs is usually the only personnel requirement
9	Reppert, R. T., et al. 1979	Yes	No	The resource manager may require field and laboratory assistance to implement the procedure. It will be difficult for a resource manager to evaluate all functions

(Continued)

(Sheet 2 of 4)

Table 3 (Continued)

Methodology Number	Citation	Resource Manager	Interdisciplinary Team	Implications Relative to User Needs
10	Schuldiner, P. W., et al. 1979	No	Yes	The interdisciplinary team should include ecologists, hydrologists, planners, geologists, limnologists, chemical engineers, soil scientists, biologists, and zoologists
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	No	Yes	The interdisciplinary team should include hydrologists, biologists, chemists, climatologists, sanitary engineers, and possibly others
12	Smardon, R. C. 1972	Yes	No	Visual-cultural values could be evaluated fairly easily by a resource manager without requiring special training in the use of the procedure
13	Solomon, R. C., et al. 1977	No	Yes	The interdisciplinary team should include an ecologist, economist, engineer, sociologist, and an anthropologist
14	State of Maryland. Dept of Natural Resources. Undated	Yes	No	A resource manager with a background in wildlife biology and plant ecology is required
15	U. S. Army Engineer Division. Lower Miss. Valley (HES). 1980	No	Yes	The interdisciplinary team* should include chemists, hydrologists, limnologists, ecologists, wildlife biologists, and botanists

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* The authors have indicated that the interdisciplinary team should include fish and/or wildlife biologists. Other needed data available in literature and district files.

(Continued)

(Sheet 3 of 4)

Table 3 (Concluded)

Methodology Number	Citation	Resource Manager	Interdisciplinary Team	Implications Relative to User Needs
16	U. S. Army Engineer Division. New England. 1972	No	Yes	The procedure requires an interdisciplinary team composed of hydrologists, ecologists, economists, engineers, historians, archeologists, outdoor recreational planners, and others
17	U. S. Department of Agriculture. 1978	Yes	No	An interdisciplinary team comprised of a plant ecologist, hydrologist, ichthyologist, wildlife biologist, recreation specialist, and a landscape architect could facilitate the evaluation. However, only a professional natural resource planner is required
18	U. S. Fish and Wildlife Service (HEP). 1980	Yes	No*	A certified HEP evaluator is required
19	Virginia Institute of Maine Science. Undated	Yes	No	A resource manager with a background in plant and animal ecology is the only personnel requirement
20	Winchester, B. H., and Harris, L. D. 1979	Yes	No	A resource manager with a general technical background is the only personnel requirement

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* Not required in HEP, but encouraged by the U. S. Fish and Wildlife Service by all its employees who use HEP.

(Sheet 4 of 4)

Table 4

Summary of the Data Requirements of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
1	Brown, A., et al. 1974.	Aerial photographs, topographic maps, surficial geology maps, pertinent literature, and field reconnaissance	Value judgments and quantitative information	None	Resource manager should consult specialists for the interpretation of critical data
2	Dee, N., et al. 1973.	Obtained from historical records or from several different measurements that are related; topographic maps, wildlife lists, plant species lists, cultural, historical, and educational/scientific information	Interdisciplinary team assigns points to parameters. Parameter weights are assigned by quantifying research team's subjective value judgments	None stated, but seasonal limitations may be imposed on the collection of some data	Disagreements may occur over the relative values of the parameters
3	Fried, E. 1974	Aerial photographs, maps, alkalinity determinations, species lists, vegetative interspersion, vegetation classes, and vegetative cover	Value judgments and quantitative information	None stated, but possibly seasonal limitations	A resource manager may be necessary to edit results obtained by field workers
4	Galloway, G. E. 1978	Extensive data requirements dependent upon the type of parameters chosen to evaluate; preliminary data include maps and detailed species lists	Interdisciplinary team utilizes value judgments and quantitative data. A team of laymen is required to weigh parameter values	None	The procedure is time-consuming and requires extensive coordination between and among the team of scientists and laymen

(Continued)

(Sheet 1 of 5)

Table 4 (Continued)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
5	Golet, F. C. 1973.	Aerial photographs, topographic maps, surficial geology maps; full reconnaissance to obtain wetland subclasses, vegetative interspersion, and water chemistry data	Value judgments and quantitative data	None	Resource manager must be familiar with vegetation and have a good background in wildlife management
6	Gupta, T. R., and Foster, J. H. 1973.	Maps and aerial photographs, limited field data	Value judgments are converted into numerical values	None	The procedure may be too superficial for general use
7	Kibby, H. V. 1978.	Determination of wetland size, periodicity of water exchanges, work review, net primary productivity data	Primarily value judgments, but some quantitative data	None	The procedure may be too superficial for general use
8	Larson, J. S., et al. 1976.	Extensive data requirements; maps, aerial photographs, transmissity, water storage, and water quality data	Value judgments and quantitative data	None	Procedure results should be monitored carefully for assessment of red flag features
9	Keppert, R. T., et al. 1979.	Maps, charts, aerial photographs, plant and animal species lists, basic hydrology data	Value judgments and quantitative data	None	Additional personnel are likely needed to collect and interpret data

(Continued)

(Sheet 2 of 5)

Table 4 (Continued)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
10	Schuldiner, P. W., et al. 1979	Extensive data requirements, plant and animal lists, primary and secondary productivity, basic hydrology data, determination of potential impacts	Value judgments and quantitative data	Basic hydrology data must be collected periodically for at least one year	The user must be willing to commit large amounts of time and resources to an evaluation
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Extensive hydrology related data requirements, annual water budgets, evapotranspiration rates, mass loadings, etc.	Value judgments based primarily on qualitative data	Hydrology data must be collected on a seasonal basis for at least one year	Extensive amounts of field and laboratory equipment are necessary to implement the procedure
12	Smardon, R. C. 1972	Topographic maps, aerial photogrammetric land use information, cover maps, surficial and bedrock, geology maps, and data obtained from field inspections	Primarily value judgments	None	The user may need training in general principles before the procedure is applied
13	Solomon, R. C., et al. 1977	Interdisciplinary team must decide data requirements	Value judgments and quantitative data	None	The procedure requires large amounts of time, resources, and coordination for implementation
14	State of Maryland. Department of Natural Resources.	Maps, aerial photographs, and field vegetative data	Value judgments and quantitative data	None, but seasonal limitations may be placed on the identification of plant species	The resource manager must be familiar with vegetation and wildlife food value of various plants

(Continued)

(Sheet 3 of 5)

Table 4 (Continued)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	Extensive amounts of habitat data; species lists, plant cover, vegetation sampling, data maps, etc.*	Focus on quantitative data; value judgments placed on habitat value	None stated; but seasonal limitations are imposed for some parameters**	Personnel should be trained and certified before attempting to utilize the procedure†
16	U. S. Army Engineer Division, New England. 1972.	Extensive date requirements, wildlife resources, hydrology, hydraulics, geology, demography, archeology, etc.	Value judgments based primarily on floodwater storage capacity of wetlands	Seasonal and possibly other limitations	The Charles River project required extensive citizen participation; the project had extensive time and cost requirements
17	U. S. Department of Agriculture. 1978.	Maps, field analysis, forest management practices, flood control information, species lists, rare and endangered species lists	Value judgments and quantitative information; primarily value judgments	None	The procedure may be too superficial for certain uses. Only a generalized evaluation is possible
18	U. S. Fish and Wildlife Service (HEP). 1980.	Aerial photographs, determination of plant cover types, species lists, topographic maps, photogrammetric information, and water gauging station records	Focus on quantitative data; value judgments placed on habitat value	None	Personnel must be trained and certified before the procedure can be used successfully

(Continued)

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* "Limited amount of terrestrial habitat data easily acquired on plots by biologists. Most stream and lake data in the literature." (Author comment.)

** "However system allows for these limitations." (Author comment.)

† "but detailed instruction will allow its use without extensive training." (Author comment.)

(Sheet 4 of 5)

Table 4 (Concluded)

Methodology Number	Citation	Types of Data Required	Measurement Techniques	Limitations Imposed on Data Collection	Implications Relative to User Needs
19	Virginia Institute of Marine Science. Undated	Reports, maps, aerial photographs, onsite inspections	Value judgments and quantitative data	None	Procedure is limited to applications only in coastal tidal marshes that are flooded daily
20	Winchester, B. H., and Harris, L. D. 1979	Aerial photgraphs, plant and animal species lists, data concerning vegetative structural diversity	Primarily value judgments	None	Results obtained may be too superficial and generalized for some purposes. A rapid evaluation is possible from limited amounts of data

(Sheet 5 of 5)

Table 5

Summary of the Red Flag Features and the Extent of Field Testing of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features*	Extent of Field Testing**	Need for Field Testing
1	Brown, A., et al. 1974	None	14 wetland sites in Arkansas were evaluated and ranked by the authors	Additional field testing by other individuals is desirable
2	Dee, N., et al. 1973	Elements of the environment that may be changed adversely are represented as major or minor red flags. Interdisciplinary team must make determinations	Field tested in a portion of the Bear River project in Utah, Idaho, and Wyoming by the Battelle Laboratory	Field testing specifically, for potential impacts in wetlands is needed. Procedure was developed for large-scale Water Resources projects
3	Fried, E. 1974	None	Field testing was conducted by 12 field workers in various regions of New York. 130 wetlands were noted during 1973	Additional field testing results would be useful
4	Galloway, G. E. 1978	Nine critical indicators of wetland quality were proposed. Interdisciplinary team selects 6 of the 9 that best represent wetland under consideration. Presence of endangered species, fish and other aquatic ecosystems, wildlife and other terrestrial ecosystems, waterfowl, uniqueness, appearance, natural protection, life-cycle support, and historical-cultural. Only the endangered species category may be a red flag feature	The procedure has not been field tested; hypothetical examples were given	Field testing is needed

(Continued)

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* Does the procedure have "red flag" features; features that emphasize key, sensitive wetland functions?

** Has the procedure been field tested and what has been the extent of field testing?

(Sheet 1 of 4)

Table 5 (Continued)

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features	Extent of Field Testing	Need for Field Testing
5	Golet, F. C. 1973	Not listed here, but red flags are included in the author's contribution to a document published later (see Larson, ed. 1976)	Field testing was not discussed in the document	Field testing is needed
6	Gupta, T. R., and Foster, J. H. 1973	None listed, but red flags were included in a document published later by members of the research team (see Larson, ed. 1976)	Field testing was not discussed	Field testing is needed
7	Kibby, H. V. 1978	None listed	Field testing was not discussed	Field testing is needed
8	Larson, J. S., ed. 1976	Eleven red flag features are proposed: (1) the presence of rare, restricted, endemic, or select flora or fauna, (2) presence of flora of unusually high visual quality and infrequent occurrence, (3) the presence of flora or fauna at, or very near, the limits of this range, (4) the juxtaposition, in sequence, of several stages of hydrarch succession, (5) high production of native waterfowl species, (6) use by great numbers of migratory birds, (7) outstanding geomorphological features, (8) availability of information concerning the wetland, (9) presence of outstanding archeological evidence, (10) wetlands that are relatively scarce in a given physiographic region, and (11) wetlands that are links in a system of waterways....Theoretically all wetlands may contain red flag features. Investigators could tend to place all wetlands in a "preservation category." A detailed wetland evaluation (Phases II and III) should be performed	Field testing results not stated. Methodology applied in modified form by Soil Conservation Service in Mass., in Rhode Island (wildlife model), and in the Northeast and Lake states.	Field testing is needed

(Continued)

(Sheet 2 of 4)

Table 5 (Continued)

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features	Extent of Field Testing	Need for Field Testing
9	Reppert, R. T, et al. 1979	Endangered or threatened species	EPA and Corps of Engineers field tested the procedure during training courses in 1977. Results were not discussed. EPA has used the procedure in Pennsylvania	Additional field testing is needed
10	Schuldiner, P. W., et al. 1979	The authors used the same red flag features proposed by Larson (ed.) 1976; an extensive list of red flags was proposed	Field testing (conducted at 8 sites in the U. S.) involved retrospective analyses of wetlands in which highway-induced changes had already taken place	Additional field testing is needed
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979.	None	None	Field testing is needed
12	Smardon, R. C. 1972	The author used essentially the same red flag features that were proposed by Larson (ed.) 1976	Field testing was conducted by the author in inland wetlands in Mass.	Additional field testing is needed
13	Solomon, R. C., 1977	None	The procedure was field tested on the Tensas project	Additional field testing is needed
14	State of Maryland. Dept of Natural Resources. Undated	None	Previous field testing in Maryland resulted in the formulation of the current procedure	Additional field testing is needed

(Continued)

(Sheet 3 of 4)

Table 5 (Concluded)

Methodology Number	Citation	Red Flag Features--Assessment of Red Flag Features	Extent of Field Testing	Need for Field Testing
15	U. S. Army Engineer Division. Lower Miss. Valley (HES). 1980	None	HES is being used by all districts in the Lower Mississippi Valley Division (St. Louis, Memphis, Vicksburg, and New Orleans)	Field testing by other agency personnel would be useful; was tested by New England Research, Inc., for IWR in 1980
16	U. S. Army Engineer Division. New England. 1972	Wetland had to be at least 100 acres and have a capacity to store large volume of floodwater	Field testing has not been conducted outside the project area of the Charles River, Mass.	The project was unique to the region and field testing is likely not possible for other regions
17	U. S. Department of Agriculture. 1978	None	Field testing was conducted by Soil Conservation Service and Mass. Water Resources personnel in Mass.; 223 wetlands were evaluated	Additional field testing would be useful
18	U. S. Fish and Wildlife Service (HEP). 1980	Identifies species sensitive to land use actions, species with key roles in the ecological community, a species representing groups of species utilize a common resource	The procedure has been tested by U. S. Fish and Wildlife Service during its development; currently being tested by the Corps of Engineers and the U. S. Fish and Wildlife Service	Further testing should be done to evaluate assumptions which are the basis of HEP
19	Virginia Institute of Marine Science. Undated	None	Results of possible field testing were not discussed in the report	Field testing is needed
20	Winchester, B. H., and Harris, L. D. 1979	None	Field testing has been conducted by the authors	Additional field testing should be conducted by state and federal agencies

(Sheet 4 of 4)

Table 6

Summary of the End Products and the Responsiveness Features of 20 Wetland Evaluation Procedures

Methodology Number	Citation	End Products*	Responsiveness**		Does Procedure Assess Major and Minor Impacts†
			Quick Answers	Detailed Answers	
1	Brown, A., et al. 1974	Numerical ranking of similar or dissimilar wetland types	Relatively quick answers	Only one type of answer is possible	NA
2	Dee, N., et al. 1973	Numerical rating expressed in environmental impact units; scores with and without proposed project	No	Detailed answers only	Yes

(Continued)

Note: NA. Not addressed.

* What type of end products or what type of evaluation summary is provided by the procedure?

** Does the procedure have the responsiveness or flexibility to provide quick answers from limited data and refined answers from additional data? It is assumed that a quick answer may be obtained within one day to one week; it is assumed that a detailed answer may require more than one week of effort; it is assumed that a relatively quick answer can be obtained with about a week of effort.

† Does the procedure differentiate and assess major and minor impacts of activities in wetlands? Only on-site impacts are considered.

(Sheet 1 of 5)

Table 6 (Continued)

Methodology Number	Citation	End Products	Responsiveness Quick Answers	 Detailed Answers	Does Procedure Assess Major and Minor Impacts
3	Fried, E. 1974	A numerical priority rating value of per-acre desirability for wetland acquisition	Relatively quick answers	No	NA
4	Galloway, G. E. 1978	Graphic displays; computer printouts of numerical values	No	Yes	Yes; major and minor impacts could be identified by interdisciplinary team or by the team of laymen
5	Golet, F. C. 1973	Numerical rating of relative wildlife value	Relatively quick answers	Only one type of answer is possible	No
6	Gupta, T. R., and Foster, J. H. 1973	Numerical rating of scenic value	Yes	No	No
7	Kibby, H. V. 1978	Narrative report; subjective determination of wetland effects on water quality	Yes	No	No
8	Larson, J. S., ed. 1976	Numerical rating that includes values for a number of wetland functions	Yes	Yes	No††

(Continued)

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†† J. S. Larson has indicated that the procedure is useful for assessing major and minor impacts.

(Sheet 2 of 5)

Table 6 (Continued)

Methodology Number	Citation	End Products	Responsiveness		Does Procedure Assess Major and Minor Impacts
			Quick Answers	Detailed Answers	
9	Reppert, R. T., et al. 1979	Narrative summary when only one site alternative is available; numerical rating if several wetlands are compared	Yes	No	No
10	Schuldiner, P. W., et al. 1979	Matrix and flow charts of ecological consequences of construction activities	No	Yes	Yes; procedure is very effective in assessing major and minor impacts
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Ratings of high, moderate, or low potential for various hydrology functions	No	Yes, general qualitative answers	No
12	Smardon, R. C. 1972	Numerical ratings for visual-cultural values	Relatively quick answers	Only one type of answer possible	No
13	Solomon, R. C., et al. 1977	Coefficient matrix which identifies the most beneficial or least detrimental project alternatives	No	Yes	Yes; primary, secondary, and tertiary impact levels are identified

(Continued)

(Sheet 3 of 5)

Table 6 (Continued)

Methodology Number	Citation	End Products	Responsiveness		Does Procedure Assess Major and Minor Impacts
			Quick Answers	Detailed Answers	
14	State of Maryland. Dept of Natural Resources. Undated	Numerical ratings of habitat values	Relatively quick answers	No	No
15	U. S. Army Engineer Division. Lower Miss. Valley (HES). 1980	Weighted rating values with a comparison of baseline conditions with future without project conditions, with future project conditions and with future alternative conditions	Relatively quick answers	Yes	Yes
16	U. S. Army Engineer Division. New England. 1972	The end product of the project was acquisition of wetlands	No	Yes	No
17	U. S. Department of Agriculture. 1978	Some numerical values with designated high, moderate, and low ratings for various functions; an evaluation summary sheet	Relatively quick answers	No	No‡

(Continued)

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‡ The U. S. Soil Conservation Service has indicated that the procedure is useful for impact assessment.

(Sheet 4 of 5)

Table 6 (Concluded)

Methodology Number	Citation	End Products	Responsiveness		Does Procedure Assess Major and Minor Impacts
			Quick Answers	Detailed Answers	
18	U. S. Fish and Wildlife Service (HEP). 1980	A matrix of relative quality values which may be used to give numerical comparisons, predictions, and baseline assessments; tables and forms	Relatively quick answers	Yes	Yes; assessment of gain or loss of habitat quality with and without proposed action overtime
19	Virginia Institute of Marine Science. Undated	Numerical rating of relative ecological significance	Relatively quick answers	No	No
20	Winchester, B. H., and Harris, L. D. 1979	Numerical rating	Yes	Yes	No

(Sheet 5 of 5)

Table 7

Summary of the Applicability Features to Various Types of Administrative Needs of 20 Wetland Evaluation Procedures

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
1	Brown, A., et al. 1974	Not applicable; evaluation on only habitat functions	Applicable; does not have extensive time requirements, requires moderate to low technical skills, data, and degree of accuracy	Not applicable	Some application	Applicable; alternative wetlands may be identified	Applicable; high quality wetlands could be identified by the ranking process
2	Dee, N., et al. 1973	Applicable; developed for long-term Water Resources projects, interdisciplinary team approach	Not applicable; requires extensive amounts of time	Applicable; determine major and minor impacts and project alternatives	Not applicable	Not applicable	Not applicable
3	Fried, E. 1974	Not applicable	Not applicable	Not applicable	Not applicable	Applicable; may be useful for making "trade-offs"	Applicable; specifically developed for acquisition needs in New York; procedure also contains a separate economic evaluation instrument
4	Galloway, G. E. 1978	Applicable; requires extensive time requirements, graphic display of evaluation results	Not applicable	Applicable; impacts determined for various sites in wetland and watershed; utilizes expertise of interdisciplinary team, laymen, and project engineer	Not applicable	Not applicable	Not applicable
5	Golet, F. C. 1973	Not applicable	Applicable (habitat values); no extensive time or data requirements	Not applicable	Applicable; can be used to manage for maximum wildlife production and diversity	Applicable; numerical ranking may identify wetlands for possible "trade-offs"	Applicable; high quality wetlands may be identified for possible acquisition

(Continued)

Table 8 further describes these administrative needs.

(Sheet 1 of 4)

Table 7 (Continued)

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
6	Gupta, T. R., and Foster, J. H. 1973	Not applicable	Applicable; must be used in conjunction with other procedures because only scenic values are evaluated	Not applicable	Not applicable	Not applicable	Applicable; wetlands of outstanding scenic quality could be identified for purchase
7	Kibby, H. V. 1978	Not applicable	Applicable; does not require extensive time requirements, technical skills, or high degree of accuracy to produce general evaluation of water quality	Not applicable	Not applicable	Not applicable	Not applicable
8	Larson, J. S., ed. 1976	Not applicable**	Applicable; numerous functions are evaluated in a time- and cost-efficient manner	Not applicable**	Applicable; submodels in the procedure may be useful (habitat); management of visual-cultural attributes	Applicable; numerical ranking instrument may allow "trade-offs"	Applicable; high quality wetlands could be identified by "red flag" features
9	Reppert, R. T., et al. 1979	Not applicable†	Applicable; a narrative evaluation summary can be prepared in a short time frame	Not applicable	Limited application	Applicable; lower quality wetlands could be identified for alternative development sites	Limited application; high quality wetlands not specifically "earmarked"

(Continued)

** J. S. Larson indicated that the procedure is applicable to project planning and site selection and impact assessment.

† R. T. Reppert has indicated that the methodology is applicable for preliminary project planning.

(Sheet 2 of 4)

Table 7 (Continued)

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
10	Schuldiner, P. W., et al. 1979	Applicable; requires extensive time requirements, large amounts of data, high degree of accuracy, and technical skills for biological and hydrological functions	Not applicable	Applicable; determination of high, moderate, and low impacts of physical structures on habitat and hydrology values of wetlands	Not applicable	Applicable; procedure specifically identifies mitigation practices to avoid or reduce impacts	Not applicable
11	Stearns, Conrad, and Schmidt - Consulting Engineers. 1979	Applicable; requires extensive amounts of time, expertise, and accuracy for implementation. A thorough hydrological investigation is required	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
12	Smardon, R. C. 1972	Not applicable	Applicable; no extensive time or technical skill requirements	Not applicable	Not applicable	Applicable; trade-offs may be possible by an identification of low quality wetlands	Applicable; high quality wetlands can be identified from red flag features
13	Solomon, R. C., et al. 1977	Applicable (Water Resource projects); extensive time, expertise, and degree of accuracy requirements	Not applicable	Applicable; interdisciplinary team determination	Not applicable	Not applicable	Not applicable
14	State of Maryland. Dept of Natural Resources. Undated	Not applicable	Applicable; time, cost, technical skill, and degree of accuracy requirements are moderate (habitat)	Not applicable	Applicable; for site-specific management needs	Applicable; numerical rankings may be useful	Applicable; may be used to identify high quality wetlands

(Continued)

(Sheet 3 of 4)

Table 7 (Concluded)

Methodology Number	Citation	Project Planning and Site Selection	Regulatory Actions	Impact Assessment	Management	Mitigation	Acquisition Needs for Preservation
15	U. S. Army Engineer Division, Lower Miss. Valley (HES). 1980	Applicable	Not applicable††	Applicable	Applicable for assessing alternative management plans	Not applicable	Applicable for determining habitat value for acquiring mitigation lands
16	U. S. Army Engineer Division, New England. 1972	Applicable; requires extensive time, costs, expertise, and levels of accuracy for implementation	Not applicable	Not applicable	Not applicable	Not applicable	Not applicable
17	U. S. Department of Agriculture. 1978	Not applicable	Applicable; can be used to evaluate a variety of functions in a cost-, and time-efficient fashion	Not applicable‡	Not applicable	Not applicable	Applicable; high quality wetlands could be identified for possible purchase
18	U. S. Fish and Wildlife Service (HEP). 1980	Applicable; usually requires extensive time and costs. Requires expertise and identifies levels of accuracy for application	Applicable‡‡	Applicable	Applicable	Applicable; can be used to determine acreage needed to maintain habitat quality level and best means to offset potential loss in quality	Applicable
19	Virginia Institute of Marine Science. Undated	Not applicable	Applicable	Not applicable	Applicable	Applicable	Not applicable
20	Winchester, B. H., and Harris, L. D. 1979	Not applicable§	Applicable; does not require extensive time, expertise, and data requirements	Not applicable	Not applicable	Some application	Possible application; numerical rankings may be useful for determination of high quality wetlands

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†† "Can be used to evaluate impacts on wetlands." (Author comment.)

‡ The U. S. Soil Conservation Service has indicated that the methodology is applicable to impact assessment.

‡‡ The authors have indicated that the procedure is applicable to regulatory needs but is frequently limited because of the time requirement and manpower funding limitations. A decision must be based on individual user needs.

§ The author indicated that the methodology is relevant to project planning and site selection.

(Sheet 4 of 4)

Table 8

Summary of Administrative Needs, Basic Administrative Requirements, and Available Wetland Evaluation Procedures that Address Administrative Needs

Administrative Needs	Time	Basic Requirements Technical Skills	Data	Degree of Accuracy	Pertinent Wetland Evaluation Procedures
Project planning and site selection	Long (years)	High	High	High	U. S. Fish and Wildlife Service,1980 (habitat); U. S. Army Engineer Division, Lower Mississippi Valley, 1980 (habitat); Dee, et al., 1973; Galloway, 1978; Schuldiner, et al., 1979 (hydrology and biological impacts); Stearns, Conrad, and Schmidt - Consulting Engineers, 1979; Solomon, et al., 1977; U. S. Army, New England, 1972
Regulatory actions	Short, days or 1-3 months	Moderate	Low to moderate	Moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Gupta and Foster, 1973 (scenic value); Kibby, 1978 (water quality); Larson, ed., 1976; Reppert, et al., 1979; Smardon, 1972 (visual-cultural); State of Maryland (habitat); U.S.D.A., 1978; Virginia Institute of Marine Science (habitat); Winchester and Harris, 1979 (habitat); U. S. Fish and Wildlife Service, 1980 (habitat), (see note in Table 7)
Impact assessment	Short to moderate	Moderate	Moderate	Moderate	Dee, et al., 1973; Galloway, 1978; Schuldiner, et al., 1979 (hydrological and biological impacts); Solomon, et al., 1977; U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer Division, Lower Mississippi Valley, 1980 (habitat)

(Continued)

Table 8 (Concluded)

Administrative Needs	Time	Basic Requirements		Degree of Accuracy	Pertinent Wetland Evaluation Procedures
		Technical Skills	Data		
Management	Short to moderate	Moderate	Moderate	Moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Larson, ed., 1976; State of Maryland (habitat); Virginia Institute of Marine Science (habitat); U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer, Division, Lower Mississippi Valley, 1980 (habitat).
Mitigation Requirements	Short to moderate	Moderate	Low to moderate	Low to moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Fried, 1974 (habitat); Larson, ed., 1976; Reppert, et al., 1979; Schuldiner, et al., 1979; Smardon, 1972 (visual-cultural); State of Maryland (habitat); Virginia Institute of Marine Science (habitat); U. S. Fish and Wildlife Service, 1980 (habitat); U. S. Army Engineer Division, Lower Mississippi Valley, 1980 (habitat)
Acquisition Needs for Preservation	Several months to one year	Moderate	Moderate	Moderate	Brown, et al., 1974 (habitat); Golet, 1973 (habitat); Fried, 1974 (habitat); Gupta and Foster, 1973 (scenic value); Larson, ed., 1976; Smardon, 1972 (visual-cultural); State of Maryland (habitat); U.S.D.A., 1978; Winchester and Harris, 1979 (habitat); U. S. Fish and Wildlife Service,1980 (habitat), U. S. Army Engineer Division, Lower Mississippi River Valley, 1980 (habitat)

Table 9

Summary of Documents Not Meeting Evaluation Criteria

Methodology Number	Citation	Methodology*	Wetland Functions**	Nonmonetary Assessment†	Decision Rationale
a	Bara, M. O., et al. 1977	No	Yes	Yes	Document provides guidelines for reviewing permit applications in South Carolina, but the purpose of the document was not to evaluate wetland functions
b	Battelle-Pacific Northwest Laboratories. 1974	Yes	No	Yes	Procedure was designed for the evaluation of social, economic, and environmental trade-offs in the analysis of nuclear plant siting options
c	Belknap, R. K., and Furtado, J. G. 1967	No	No	No	Document is a review of three other works. No wetland functions are specifically evaluated
d	Benson, D., and Perry, R. F. 1965	No	Yes	No	Document does not contain a procedure for evaluating wetlands. Wetland functions were discussed, but the value of a marsh was measured in monetary terms

(Continued)

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* Does the document provide methodologies or procedures?

** Does the methodology address wetland functional values?

† Does the methodology evaluate wetland functions by methods other than monetary values?

(Sheet 1 of 5)

Table 9 (Continued)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
e	California Coastal Commission. 1979	No	Yes	Yes	Document provides guidelines for reviewing permit applications in coastal areas of California. The purpose of the document was not to evaluate wetland functions
f	Commonwealth of Virginia. 1974	No	Yes	Yes	Document provides guidelines for reviewing permit applications in Virginia. The objective of the document was not to evaluate wetland functions
g	Coordinating Council on the Restorations of the Kissimmee River Valley and the Creek-Nubbin Slough Basin. 1978	No	Yes	No	Document does not provide a methodology for evaluating wetland functions. The objective of the document was to review efforts in the watershed of this area
h	Foster, J. H. 1978	No	No	No	Document does not provide a methodology. Wetland functions are not specifically addressed. The objective of the paper was to suggest monetary values for wetlands

(Continued)

(Sheet 2 of 5)

Table 9 (Continued)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
i	Fritz, W. R. 1978	No	Yes	Yes	Document does not provide a methodology for evaluating a wetland for functional values. The objective of the document was to assess cypress wetlands for wastewater treatment
j	Gosselink, J. G., et al. 1974	Yes	Yes	No	Value of a tidal marsh ecosystem is translated into monetary values. The purpose of the document was to illustrate economic values of wetlands
k	Gupta, T. R. 1972	No	Yes	No	Document does not provide procedures for evaluating wetland function; monetary values are implied
l	Hill, D. 1976	Yes	Yes	No	The methodology evaluates wetlands only in monetary terms
m	Larson, J. S. 1973	No	Yes	Yes	Document provides a good discussion of wetland functional values, but it does not contain a procedure for evaluating wetlands

(Continued)

(Sheet 3 of 5)

Table 9 (Continued)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
n	New York State Department of Environmental Conservation. Undated	No	Yes	Yes	Document does not provide a procedure for evaluating wetland functions. The objective of the report was to interpret New York State statutes concerning wetlands
o	Shabman, L. A., et al. 1979	Yes	Yes	No	Procedure is based upon monetary values of wetlands
p	Silberhorn, G. M., et al. 1974	No	Yes	Yes	Document does not contain a procedure for evaluating wetlands. Wetland functions were discussed briefly; monetary values of wetlands were not stated
q	U. S. Department of Agriculture. 1974	No	Yes	Yes	The purpose of the document was not to provide a procedure for evaluating wetlands. Soil Conservation Service policies, procedures, and guidelines for preparing Environmental Impact Statements were discussed
r	U. S. Environmental Protection Agency. 1976	Yes	No	Yes	Document does not address wetland functions
s	Wharton, W. H. 1970	Yes	Yes	No	Procedures are associated with monetary values for functions

(Continued)

(Sheet 4 of 5)

Table 9 (Concluded)

Methodology Number	Citation	Methodology	Wetland Functions	Nonmonetary Assessment	Decision Rationale
t	Whitaker, G. A., and McCuen, R. H. 1975	Yes	No	Yes	Methodology does not address wetland functional values
u	Williams and Works. 1979	No	Yes	Yes	Document does not provide a procedure for evaluating wetland functions. The objective was to examine artificial wetlands for wastewater treatment

(Sheet 5 of 5)

APPENDIX C

Abstracts of Wetland
Evaluation Methodologies
Reviewed in Lonard
et al. (1981)

Citation:

Brown, A., Kittle, P., Dale, E. E., and Huffman, R. T. 1974. "Rare and Endangered Species, Unique Ecosystems and Wetlands," Department of Zoology and Department of Botany and Bacteriology. The University of Arkansas, Fayetteville, Ark.

Abstract:

The Arkansas Wetlands Classification System contains a two-part, multivariate approach for evaluating freshwater wetlands for maximum wildlife production and diversity. Initially Arkansas wetlands were qualitatively classified as prime or nonprime wetland habitats according to use by man. A numerical value for a wetland was determined by calculating a subscore which was based on the multiplication of a significance coefficient by a determined weighted value. The values for each variable were summed and a total wetland quantitative value was obtained for use by decision makers.

Citation:

Dee, N., et al. 1973. "Environmental Evaluation System for Water Resources Planning," Water Resources Research, Vol 9, No. 3, pp 523-534.

Abstract:

"The EES is a methodology for conducting environmental impact analysis. It was developed by an interdisciplinary research team and is based on a hierarchical arrangement of environmental quality indicators, an arrangement that classifies the major areas of environmental concern into major categories, components, and ultimately into parameters and measurements of environmental quality. The EES provides for environmental impact evaluations in four major categories: ecology, environmental pollution, esthetics, and human interest. These four categories are further broken down into 18 components and finally into 78 parameters. The EES provides a means for measuring or estimating selected environmental impacts of large-scale water resource development projects in commensurate units termed 'environmental impact units' (EIU). Results of using the EES include a total score in ETC 'with' and 'without' the proposed project; the difference between the two scores is one measure of environmental impact. Environmental impact scores developed in the EES are based on the magnitude of specific environmental impacts and their relative importance. Another major output from the EES is an indication of major adverse impacts called 'red flags,' which are of concern of and by themselves. These flags indicate 'fragile' elements of the environment, which must be studied in more detail." (Author abstract.)

Citation:

Fried, E. 1974. "Priority Rating of Wetlands for Acquisition," *Transactions of the Northeast Fish and Wildlife Conference*, Vol 31, pp 15-30.

Abstract:

New York State's Environmental Quality Bond Act of 1972 provided $5 million for inland wetland acquisition, $18 million for tidal wetlands acquisition, and $4 million for wetlands restoration. A priority rating system, with particular emphasis on inland wetlands, was developed to guide these programs. The governing equation was: priority rating = $(P + V + A) \times 5$, where the priority rating is per-acre desirability for acquisition, P is biological productivity, V is vulnerability, and A is additional factors. Both actual and potential conditions could be rated. The rating system was successfully applied to some 130 inland wetlands. Using a separate equation, wetland values were related to costs. (Author abstract.)

Citation:

Galloway, G. E. 1978. "Assessing Man's Impact on Wetlands," Sea Grant Publication No. UNC-SG-78-17 or UNC-WRII-78-136, University of North Carolina, Raleigh. North Carolina.

Abstract:

The Wetland Evaluation System (WES) proposed by Galloway emphasizes a systems approach to evaluate man's impact on a wetland ecosystem. Impacts are determined and compared for "with" and "without" project conditions. The advice of an interdisciplinary team as well as the input of local elected officials and laymen are included as part of the WES model. Parameters that make up a wetland are assessed at the macro-level and the results of the evaluation are displayed numerically and graphically with computer-assisted techniques.

Citation:

Golet, F. C. 1973. "Classification and Evaluation of Freshwater Wetlands as Wildlife Habitat in the Glaciated Northeast," *Transactions of the Northeast Fish and Wildlife Conference*, Vol 30, pp 257-279.

Abstract:

"A detailed classification system for freshwater wetlands is presented along with ten criteria for the evaluation of wetlands as wildlife habitat. The results are based on a 2-year field study of over 150 wetlands located throughout the state of Massachusetts. The major components of the classification system include wetland classes and subclasses, based on the dominant life form of vegetation and surface water depth and permanence; size categories; topographic and hydrologic location; surrounding habitat types; proportions and interspersion of cover and water; and vegetative interspersion. These components are combined with wetland juxtaposition and water chemistry to produce criteria for a wetland evaluation. Using a system of specifications and ranks, wetlands can be arrayed according to their wildlife value for decision-making." (Author abstract.) "At this point, the system has been used in numerous states on thousands of wetlands; recent revisions have resulted in such use." (F. C. Golet)

Citation:

Gupta, T. R., and Foster, J.H. 1973. "Valuation of Visual-Cultural Benefits from Freshwater Wetlands in Massachusetts," Journal of the Northeastern Agricultural Council, Vol 2, No 2, pp 262-273.

Abstract:

The authors suggested an alternative to the "willingness to pay" approaches for measuring the social values of natural open space and recreational resources. The method combines an identification and measurement of the physical qualities of the resource by landscape architects. Measurement values were expressed in the content of the political system and current public views. The procedure is demonstrated by its application to freshwater wetlands in Massachusetts.

Citation:

Kibby, H. V. 1978. "Effects of Wetlands on Water Quality," Proceedings of the Symposium on Strategies for Protection and Management of Floodplain Wetlands and Other Riparian Ecosystems, General Technical Report No. GTR-WO-12, U. S. Department of Agriculture, Forest Service, Washington, D. C.

Abstract:

Wetlands potentially have significant effects on water quality. Significant amounts of nitrogen are assimilated during the growing season and then released in the fall and early spring. Phosphorus, while assimilated by wetlands, is also released throughout the year. Some potential management tools for evaluating the effect of wetlands on water quality are discussed. (Author abstract.)

Citation:

Larson, J. S. (ed). 1976. "Models for Assessment of Freshwater Wetlands," Pub. No 32 Water Resources Research Center, University of Massachusetts, Amherst, Mass.

Abstract:

Four submodels for relative and economic evaluation of freshwater wetlands are presented within a single, three-phase eliminative model. The submodels treat wildlife, visual-cultural, groundwater, and economic values.

The wildlife and visual-cultural models are based on physical characteristics which for the most part can be measured on existing maps and aerial photographs. Each characteristic is given values by rank and coefficient. A relative numerical score is calculated for the total wetland characteristics and used to compare it with a broad range of northeastern wetlands or with wetlands selected by the user. The groundwater model places wetlands in classes of probable groundwater yield based on surficial geologic deposits under the wetland.

The economic submodel suggests values for wildlife, visual-cultural aspects, groundwater, and flood control. Wildlife values are derived from the records of state agency purchases of wetlands with sportsmen's dollars for wildlife management purposes. Visual-cultural economic values are based on the record of wetland purchases for open space values by municipal conservation commissions. Groundwater values stem from savings realized by selection of a drilled public water supply over a surface water source. Flood control values are based on U. S. Army Corps of Engineers data on flood control values of the Charles River, Massachusetts, mainstream wetlands.

The submodels are presented within the framework of an overall three-phase eliminative model. Phase I identifies outstanding wetlands which should be protected at all costs. Phase II applies the wildlife, visual-cultural, and groundwater submodels to those wetlands which do not meet the criteria for outstanding wetlands Phase III develops the economic values of the wetlands evaluated in Phase II.

The models are intended to be used by local, regional, and state resource planners and wetland regulation agencies. (Author abstract.)

Citation:

Reppert, R. T., et al. 1979. "Wetland Values: Concepts and Methods for Wetlands Evaluation," IWR Research Report 79-R-1. U. S. Army Engineer Institute for Water Resources, Fort Belvoir, Virginia.

Abstract:

The evaluation of wetlands is based on the analysis of their physical, biological, and human use characteristics. The report discusses these functional characteristics and identifies specific criteria for determining the efficiency with which the respective functions are performed.

Two potential wetlands evaluation methods are described. One is a non-quantitative method in which individual wetland areas are evaluated based on the deductive analysis of their individual functional characteristics. The other is a semiquantitative method in which the relative values of two or more site alternatives are established through the mathematical rating and summation of their functional relationships.

The specific functions and values of wetlands which are covered in this report are (1) natural biological functions, including food chain productivity and habitat, (2) their use as sanctuaries, refuges, or scientific study areas, (3) shoreline protection, (4) groundwater recharge, (5) storage for flood and storm water, (6) water quality improvement, (7) hydrologic support, and (8) various cultural values. (Author abstract.)

Citation:

Schuldiner, P. W., Cope, D. F., and Newton, R. B. 1979. "Ecological Effects of Highway Fills of Wetlands," Research Report. National Cooperative Highway Research Program Report No. 218A, Transportation Research Board, National Research Council, Washington, D. C.

and

Schuldiner, P. W., Cope, D. F., and Newton, R. B. 1979. "Ecological Effects of Highway Fills of Wetlands," User's Manual. National Cooperative Highway Research Program Report No. 218B, Transportation Research Board, National Research Council, Washington, D. C.

Abstract:

The two reports include a Research Report and a User's Manual that were prepared to provide, in concise format, guidelines and information needed for the determination of the ecological effects that may result from the placement of highway fills on wetlands and associated floodplains and to suggest procedures by which deleterious impacts can be minimized or avoided. The practices that can be used to enhance the positive benefits are also discussed. Both reports cover the most common physical, chemical, and biological effects that the highway engineer is likely to encounter when placing fills in wetlands and displays the effects and their interactions in a series of flowcharts and matrices.

Citation:

Stearns, Conrad and Schmidt - Consulting Engineers. 1979. "Analysis of Selected Functional Characteristics of Wetlands," Contract No. DACW73-78-R-0017, Reston, Virginia.

Abstract:

The investigation focused on identifying factors and criteria for assessing the wetland functions of water quality improvement, groundwater recharge, storm and floodwater storage, and shoreline protection. Factors and criteria were identified that could be used to develop procedures to assist Corps personnel in assessing the value of general wetland types and of specific wetlands in performing the functions indicated. To the extent possible, procedures were then outlined that allow the application of these criteria to specific sites.

This procedure involved a three-phase study of functional wetlands at four selected sites.

Phase I - Nationwide Survey of Material Fluxes Through Wetlands. This phase would be an extensive short-term data collection effort to obtain information on material fluxes through many different types of wetlands under widely varying conditions.

Phase II - Model Development and Verification. This phase utilizes the data base and output from Phase I to formulate and calibrate deterministic models for the water quality improvement functioning of wetlands.

Phase III - Detailed and Long-Term Field Studies. This phase includes pure and applied research. The results of Phases I and II will indicate what factors are useful for predicting the water quality improvement functioning of wetlands and those factors that seem to be important but need more study to be fully understood.

Citation:

Smardon, R. C. 1972. "Assessing Visual-Cultural Values on Inland Wetlands in Massachusetts," Master of Science Thesis. University of Massachusetts. Amherst, Mass.

Abstract:

This study deals with the incorporation of visual-cultural values of inland wetlands into the decision-making process of land use allocation of inland wetlands in Massachusetts. Visual-cultural values of inland wetlands may be defined as visual, recreational, and educational values of inland wetlands to society. The multivariate model is an eliminative and comparative model which has three levels of evaluation. The first level identifies those wetlands which are outstanding natural areas or have regional landscape value or are large wetland systems. These wetlands have top priority for preservation. The second level is a rating and ranking system. At this stage the combined natural resource values of the wetland are evaluated. Wetlands with high ratings or rank from this level are eliminated and have the next highest priority for preservation or some sort of protection. The third level evaluation considers the cultural values (i.e., accessibility, location near schools, etc.) of wetlands. The model is designed to be utilized at many different levels of decision making. For example, it can be used by state agencies, town conservation commissions, and conceivably could be used by other states in Northeastern United States. (Author abstract.)

Citation:

Solomon, R. C., et al. 1977. "Water Resources Assessment Methodology (WRAM)--Impact Assessment and Alternative Evaluation," Technical Report Y-77-1, Environmental Effects Laboratory, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.

Abstract:

The U. S. Army Crops of Engineers has been directed by various legislation, acts, and regulations to conduct systematic and comprehensive environmental planning for its activities. The thrust of this study has been to pull together the state of the art and to synthesize a WRAM for impact assessment and alternative evaluation. A review of 54 impact assessment methodologies revealed that none entirely satisfied the needs or requirements for the Corps' water resources projects and programs. However, salient features contained in several of the methodologies were considered pertinent for inclusion in

WRAM. One of the features consisted of weighting impacted variables and scaling the impacts of alternatives. The resulting weighted and scaled values are multiplied to obtain final importance values. The weighted rankings technique is the basic weighting and scaling tool used in this methodology. It consists of developing relative importance coefficient values for each variable, assigning alternative choice coefficient values to each alternative in relation to its impact on each variable, and displaying the products in a final coefficient matrix. Principal components of WRAM include assembling an interdisciplinary team; selecting and measuring assessment variables; identifying, predicting, and evaluating impacts and alternatives; and documenting the analysis. Although WRAM is presented for use by the Corps in water resources management, it does have general applicability to other resource management agencies.

Citation:

State of Maryland Department of Natural Resources. Undated. "Environmental Evaluation of Coastal Wetlands (Draft)," Tidal Wetlands Study, pp 181-208.

Abstract:

The Maryland scheme for the evaluation of coastal wetlands is based on the recognition of 32 distinct types of vegetation in the marshes and swamps of tidewater areas of the state. Rankings of vegetation types were developed and parameters for the evaluation of specific areas of wetlands were described. The application of the scheme is explained and demonstrated. Guidance is provided for the interpretation of results. The application of the Maryland scheme requires a detailed inventory of the types of vegetation in the area selected for evaluation.

Citation:

U. S. Army Engineer Division. Lower Mississippi Valley. August 1980. "A Habitat Evaluation System for Water Resources Planning," U. S. Army Corps of Engineers, Lower Mississippi Valley Division, Vicksburg, Miss.

Abstract:

A methodology is presented for determining the quality of major habitat types based on the description and quantification of habitat characteristics. Values are compared for existing baseline conditions, future conditions without the project, and with alternative project conditions. Curves, parameter characteristics, and descriptive information are included in the appendices. The Habitat Evaluation System (HES) procedure includes the following steps for evaluating impacts of a water resource development project. The steps include: (1) obtaining habitat type or land use acreage, (2) deriving Habitat Quality Index scores, (3) deriving Habitat Unit Values (4) projecting Habitat Unit Values for the future with and without project conditions, (5) using Habitat Unit Values to assess impacts of project alternatives, and (6) determining mitigation requirements.

Citation:

U. S. Army Engineer Division, New England. 1972. "Charles River. Main Report and Attachments," Waltham, Mass.

Abstract:

The study was a long-term project directed by the U. S. Army Corps of Engineers to study the resources of the Charles River Watershed in eastern Massachusetts. It had an emphasis on how to control flood damages in the urbanized lower watershed and how to prevent any significant flood damage in the middle and upper watershed. Seventeen crucial wetlands were identified. Various aspects of the watershed were studied in an interdisciplinary fashion.

Citation:

U. S. Department of Agriculture. 1978. "Wetlands Evaluation Criteria-Water and Related Land Resources of the Coastal Region, Massachusetts," Soil Conservation Services, Amherst, Mass. 01002.

Abstract:

A portion of the document (Appendix B) contains criteria used to evaluate major wetlands in the coastal region of Massachusetts. Each of the 85 wetlands which was evaluated was subjected to map study and a field examination. Ratings were assigned based on point values obtained for various attributes. A rationale for each evaluation item was developed to explain the development of the criteria.

Citation:

U. S. Department of Agriculture. 1978. "Wetlands Evaluation Criteria--Water and Related Land Resources of the Coastal Region, Massachusetts," Soil Conservation Service, Amherst, Mass. 01002

Abstract:

The study addresses water resource problems, alternatives, and needs through 1990. Results will be used to prepare a state water and related land resources plan. Appendix B, Wetland Evaluation Criteria, describes a procedure used to evaluate 85 wetlands in the coastal region. Point values on a 1 to 10 (low to high) scale were assigned to seven functional values permitting a total index value number. The criteria were developed by an interdisciplinary team of USDA specialists.

Citation:

U. S. Fish and Wildlife Service. 1980. "Habitat Evaluation Procedures (HEP) Manual (102 ESM)," Washington, D. C.

Abstract:

HEP is a method which can be used to document the quality and quantity of available habitat for selected wildlife species. HEP provides information for two general types of wildlife habitat comparisons: (1) the relative value of different areas at the same point in time; and (2) the relative value of the same area at future points in time. By combining the two types of comparisons, the impact of proposed or anticipated land and water changes on wildlife habitat can be quantified. This document describes HEP, discusses some probable applications, and provides guidance in applying HEP in the field.

Citation:

Virginia Institute of Marine Science. Undated. "Evaluation of Virginia Wetlands" (Mimeographed).

Abstract:

The authors presented a procedure to evaluate the wetlands of Virginia. Two broad categories of criteria were utilized in evaluating the ecological significance of wetlands: the interaction of wetlands with the marine environment and the interaction of the wetland with the terrestrial environment. The following formula was developed to demonstrate the incorporation of the various factors into the relative ecological significance values:

Citation:

Winchester, B. H., and Harris, L. D. 1979. "An Approach to Valuation of Florida Freshwater Wetlands," Proceedings of the Sixth Annual Conference on the Restoration and Creation of Wetlands, Tampa, Florida.

Abstract:

A procedure was presented for estimating the relative ecological and functional value of Florida freshwater wetlands. Wetland functions evaluated by this procedure include water quality enhancement, water detention, vegetative diversity and productivity, and wildlife habitat value. The field parameters used in the assessment were wetland size, contiguity, structural vegetative diversity, and an edge-to-area ratio. The procedure was field tested and was time- and cost-effective. Allowing flexibility in both the evaluative criteria used and the relative weight assigned to each criterion, the methodology is applicable in any Florida region for which basic ecological data are available. (Author abstract.)

APPENDIX D

Additional Studies
reviewed by Lonard *et al*. (1981)
that did not meet screening criteria

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APPENDIX E

Scale-weighted Checklists
developed by Nelson *et al*. (1982)

Classes of Factors in Level of Adverse Impact	Individual Factors for Consideration	Factor[1] Scale (0-3)	Factor[2] Weight (1-5)	Scaling-[3] Weighting Product (0-15)
Water dynamics:				
● TOPOGRAPHY OR BATHYMETRY	Increased substrate or soil elevations obstructing or diverting natural drainage?	____	____	____
● FLOW AND CIRCULATION	Changing currents or stream flows?	____	____	____
	Changing circulation patterns?	____	____	____
	Changing water level fluctuations?	____	____	____
● GROUND WATER[4]	Modify water tables or flows?	____	____	____
	Disrupt aquifers, springs, or wells?	____	____	____
Particulates:				
● PARTICLE SIZE AND DENSITY	Similar at extraction and disposal sites?	____	____	____
● SEDIMENTATION AND TURBIDITY	Probable sedimentation, mounding, and substrate burial?	____	____	____
	Probable erosion, sediment suspension, transport and turbidity?	____	____	____
	SUBTOTALS	____	____	____

1. Level of impact for each factor is scaled insignificant (0), minor (1), moderate (2), or major (3).
2. Factor weight from low (1) to high (5) is assigned based on relative importance of each factor.
3. Scale value is multiplied by numerical weight.
4. Not explicitly covered under Section 404 of Clean Water Act.

Appendix Table E-1. Assessment scaling-weighted checklist for physical environmental factors in dredge and fill operations (from Nelson and Associates Inc. 1981).

Classes of Factors in Level of Adverse Impact	Individual Factors for Consideration	Factor[1] Scale (0-3)	Factor[2] Weight (1-5)	Scaling-[3] Weighting Product (0-15)
Water Quality:				
● SURFACE WATER	Probable decreased dissolved oxygen or change in pH?			
	Increased nutrients, promoting salinization or eutrophication?			
	Increased bioavailability of toxic or hazardous substances?			
	Oxidized contaminants in diked upland sites, polluting the return flows?			
● GROUND WATER[4]	Oxidized contaminants in diked upland sites leaching into aquifers?			
	Migrating to open water?			
Sediments:				
● CONTAMINANT CONCENTRATIONS	Toxic or hazardous contaminants potentially present in dredged or fill material?			
	At higher concentrations than at discharge site?			
	With increased bioavailability?			
	SUBTOTALS			

---

1. Level of impact for each factor is scaled insignificant (0), minor (1), moderate (2), or major (3).
2. Factor weight from low (1) to high (5) is assigned based on relative importance of each factor.
3. Scale value is multiplied by numerical weight.
4. Not explicitly covered under Section 404 of Clean Water Act.

Appendix Table E-2. Assessment scaling-weighting checklist for chemical environmental factors in dredge and fill operations (from Nelson and Associates Inc. 1981).

Classes of Factors in Level of Adverse Impact	Individual Factors for Consideration	Factor[1] Scale (0-3)	Factor[2] Weight (1-5)	Scaling-[3] Weighting Product (0-15)
Site values:				
• ECOSYSTEM EFFECTS	Short-term disruption or long-term loss of productivity and diversity?	____	____	____
	Smothering of benthic biota without recolonization, or with recolonization where a system is stable and resilient?	____	____	____
	Chronic or acute physiological stress or bioconcentration from toxic contaminants?	____	____	____
• HABITAT VALUES	Displacement, conversion or loss of value of wetlands, lakes and streams, and at diked upland sites?[4]	____	____	____
• POPULATION VALUES	Loss of species abundance and community productivity and diversity?	____	____	____
	Of critical or preferred food sources and escape cover?	____	____	____
	Transmission of disease organisms or parasites in dredged or fill material?	____	____	____
• SEASONAL EFFECTS	Displacement or disruption of migration routes or wintering sites?	____	____	____
	Of spawning, nesting, breeding and rearing sites?	____	____	____
Special resources:				
• SPECIAL AQUATIC SITES	Displacement, conversion or modification of productive, sensitive or unique wetlands?	____	____	____
	Sand or mud flats or vegetated shallows?	____	____	____
	Riffle-and-pool stream segments?	____	____	____
	Wildlife sanctuaries or refuges?	____	____	____
• OTHER PRIME HABITATS	Displacement, conversion or modification of productive, sensitive or unique natural lakes or ponds?	____	____	____
	High value upland sites used for diked disposal?[4]	____	____	____
	Critical habitat of threatened or endangered species?	____	____	____
	SUBTOTALS	____	____	____

1. Level of impact for each factor is scaled insignificant (0), minor (1), moderate (2), or major (3).
2. Factor weight from low (1) to high (5) is assigned based on relative importance of each factor.
3. Scale value is multiplied by numerical weight.
4. Not explicitly covered under Section 404 of Clean Water Act.

Appendix Table E-3. Assessment scaling-weighting checklist for biological and ecosystem factors in dredge and fill operations (from Nelson and Associates Inc. 1981).

Classes of Factors in Level of Adverse Impact	Individual Factors for Consideration	Factor[1] Scale (0-3)	Factor[2] Weight (1-5)	Scaling-[3] Weighting Product (0-15)
Land and water use:				
• COMPATIBILITY	Use of finished disposal or fill site consistent with surrounding water and land use?[4]	____	____	____
	Dependent on water access or siting?	____	____	____
	Identified as suitable or unsuitable for dredged material or fill discharge?[4]	____	____	____
Special resources:				
• FISHERIES	Displacement or disruption of valuable sport fish populations?	____	____	____
	Commercial fish or shellfish populations?	____	____	____
• WATERFOWL AND GAME	Displacement or disruption of valuable waterfowl populations?	____	____	____
	Game bird and mammal populations?	____	____	____
• UNIQUE SITES	Displacement or disruption of valuable landscapes or views?	____	____	____
	Historic or archeological sites?	____	____	____
	SUBTOTALS	____	____	____

1. Level of impact for each factor is scaled insignificant (0), minor (1), moderate (2), or major (3).
2. Factor weight from low (1) to high (5) is assigned based on relative importance of each factor.
3. Scale value is multiplied by numerical weight.
4. Not explicitly covered under Section 404 of Clean Water Act.

Appendix Table E-4. Assessment scaling-weighting checklist for land or water use and other cultural factors in dredge and fill operations (from Nelson and Associates Inc. 1981).

Classes of Factors in Level of Beneficial Impact	Individual Factors for Consideration	Factor[1] Scale (0-3)	Factor[2] Weight (1-5)	Scaling-[3] Weighting Product (0-15)
Available actions to minimize adverse effects:[5]				
• STRUCTURAL FEATURES	Piers, culverts or pervious fills to maintain circulation?			
	Check dams or current deflectors to control increased flows?			
	Bank or dike cover and stabilization to control scouring and erosion?			
• DREDGING[4] AND DISCHARGE EQUIPMENT	Low-impact bucket, draghead or cutterhead design?			
	Low-impact discharge pipe design, submerged diffusers or silt curtains?			
	Low-ground-pressure vehicles or equipment?			
• MATERIAL PLACEMENT	Disposal in coves, depressions or thalweg to reduce flow obstruction, or in diked upland sites?[4]			
	Retention of fines inside dikes[4] with settling, coagulation, dewatering, filters and weirs?			
	Impervious liners and caps to prevent leaching, or leachate collection and treatment?			
• OTHER ACTIONS OR MEASURES	Other materials, equipment, structures, routes, scheduling, etc.?			
Habitat development:				
• NEW HABITAT	Creation of marsh or other wetlands?			
	Nesting or barrier islands or upland contained sites?[4]			
	Mud flats, sand bars, or vegetated shallows?			
• HABITAT RESTORATION	Improvement of drainage and circulation?			
	Improvement of stream riffles and pools?			
	Improvement of substrate for benthic biota or fish spawning?			
	SUBTOTALS			

1. Level of impact for each factor is scaled insignificant (0), minor (1), moderate (2), or major (3).
2. Factor weight from low (1) to high (5) is assigned based on relative importance of each factor.
3. Scale value is multiplied by numerical weight.
4. Not explicitly covered under Section 404 of Clean Water Act.
5. Alternative discharge sites require separate assessment.

Appendix Table E-5. Scaling-weighted checklist for enhancement, compensation and mitigation factors in dredge and fill operations (from Nelson and Associates Inc. 1981).

Scaling-Weighting Checklists	Weighting Subtotals[1]	Scaling-Weighting Product Subtotals[2]	
Table 6.1-4--Operations type, scale and timing factors			
Table 6.1-5--Physical environmental factors			
Table 6.1-6--Chemical environmental factors			
Table 6.1-7--Biological and ecosystem factors			
Table 6.1-8--Land or water use and other cultural factors			
ADVERSE IMPACT TOTALS[3]			☐ Overall Level of Adverse Impact[5]
Table 6.1-9--Enhancement, compensation and mitigation factors			
BENEFICIAL IMPACT TOTALS[4]			☐ Overall Level of Beneficial Impact[5]

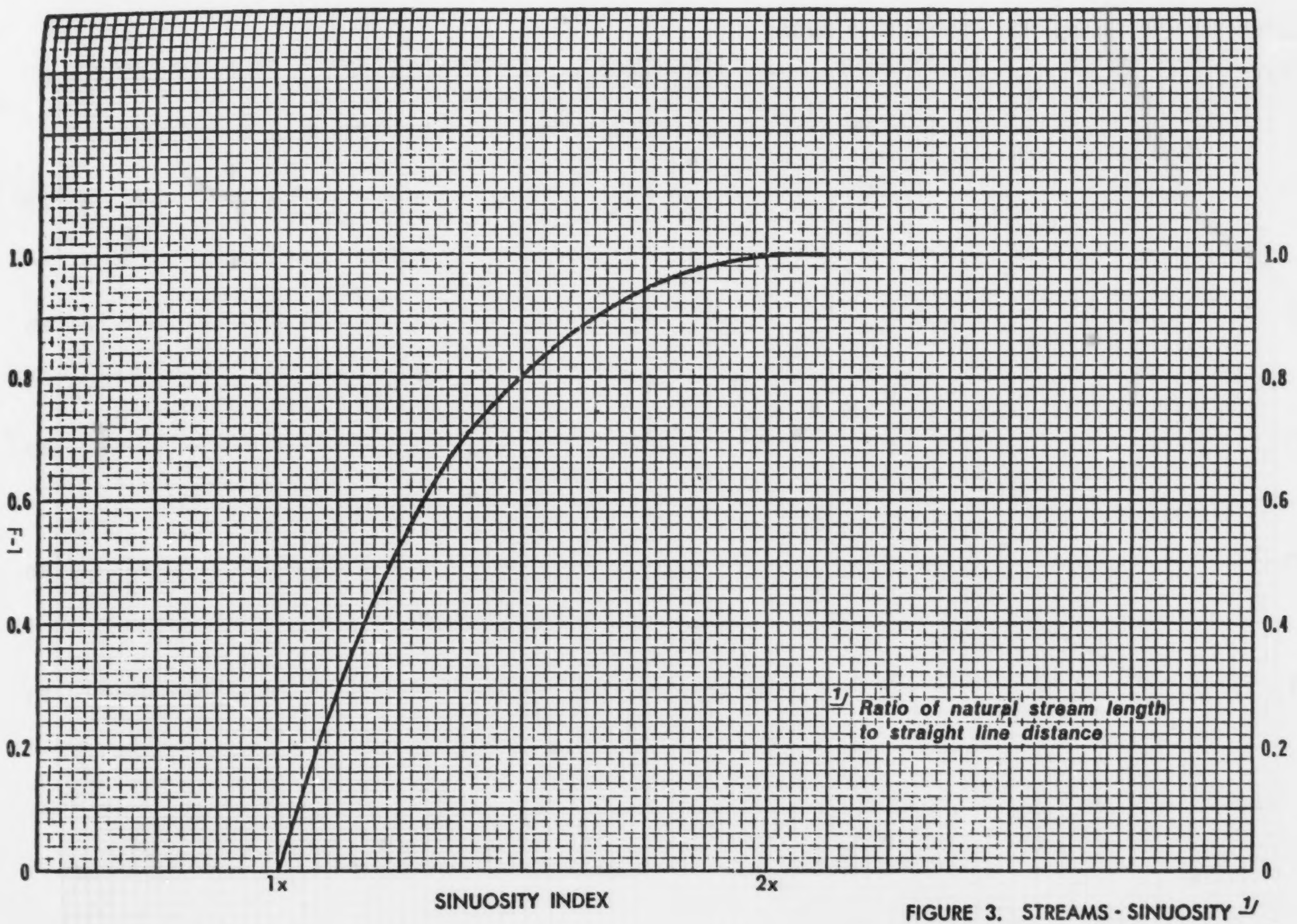
1. Add all factor weights in each of six checklists and enter in this column.
2. Add all scaling-weighting products and enter in this column.
3. Sum the factor weights and products for the five adverse impact checklists on this line.
4. Sum the factor weights and products for the beneficial impact checklist on this line.
5. Divide total products by total weights and enter in the box (nearest tenth); interpret the result using the key below.

Key: 0.0-0.9 = "Insignificant"
1.0-1.7 = "Minor"
1.7-2.3 = "Moderate"
2.4-3.0 = "Major"

Appendix Table E-6. Assessment summary for all factors of adverse and beneficial impact from dredge and fill activities (from Nelson and Associates Inc. 1981).

APPENDIX F

Example HQI Curves
used by HES (USCOE 1980)



[1] Ratio of natural stream length to straight line distance

FIGURE 3. STREAMS - SINUOSITY [1]

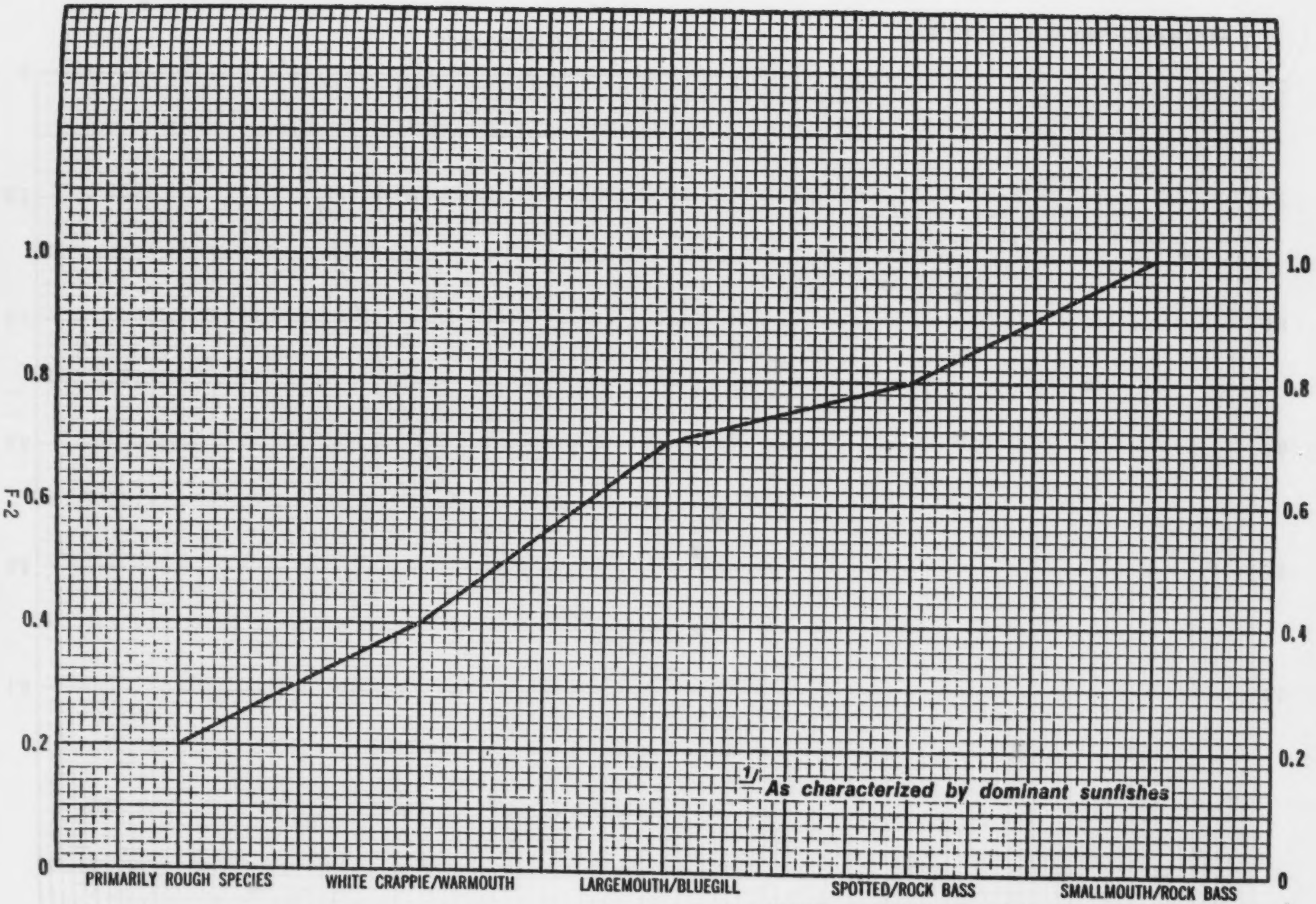


FIGURE 4. STREAMS - FISH SPECIES ASSOCIATION [1]

[1] *As characterized by dominant sunfishes*

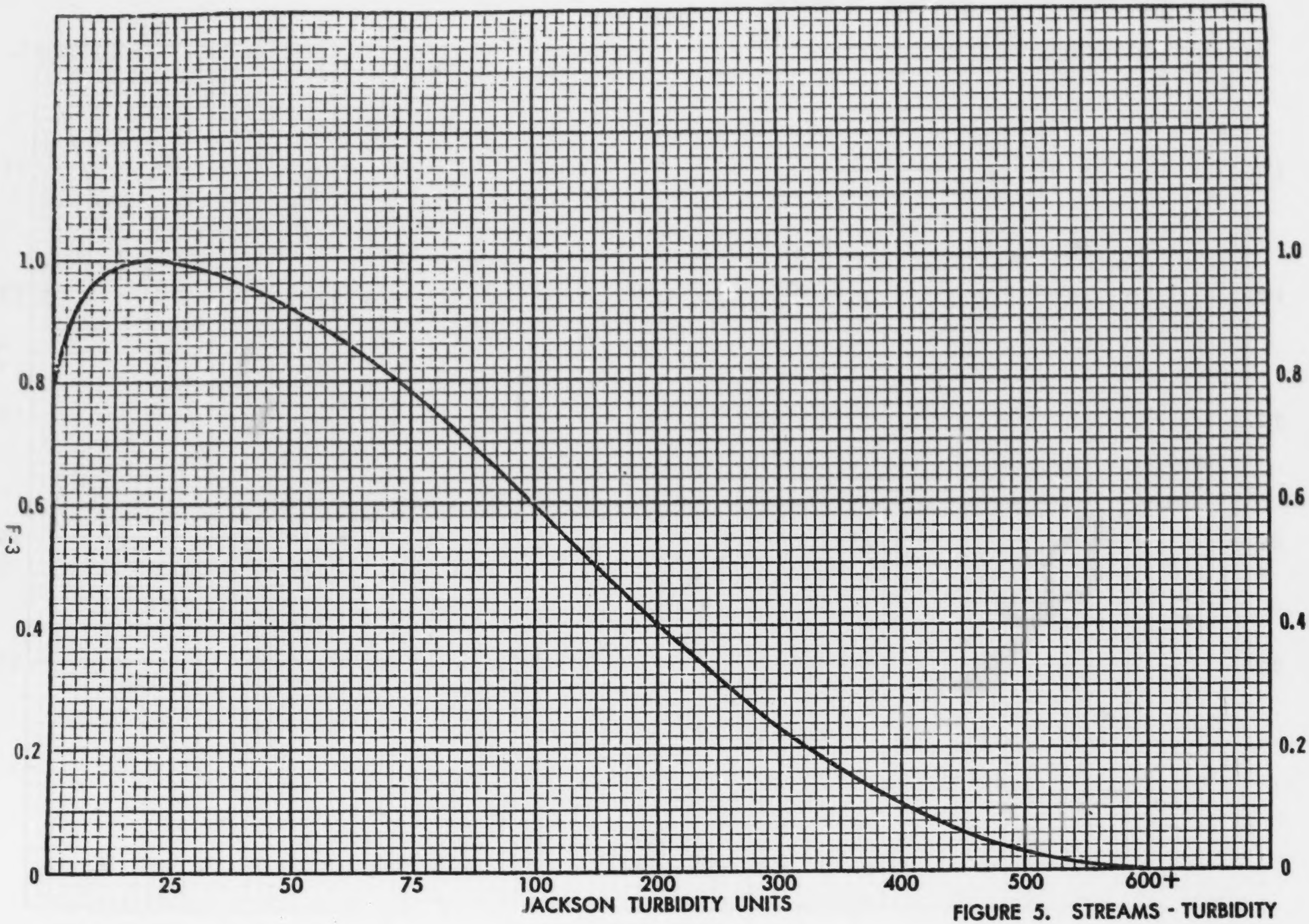


FIGURE 5. STREAMS - TURBIDITY

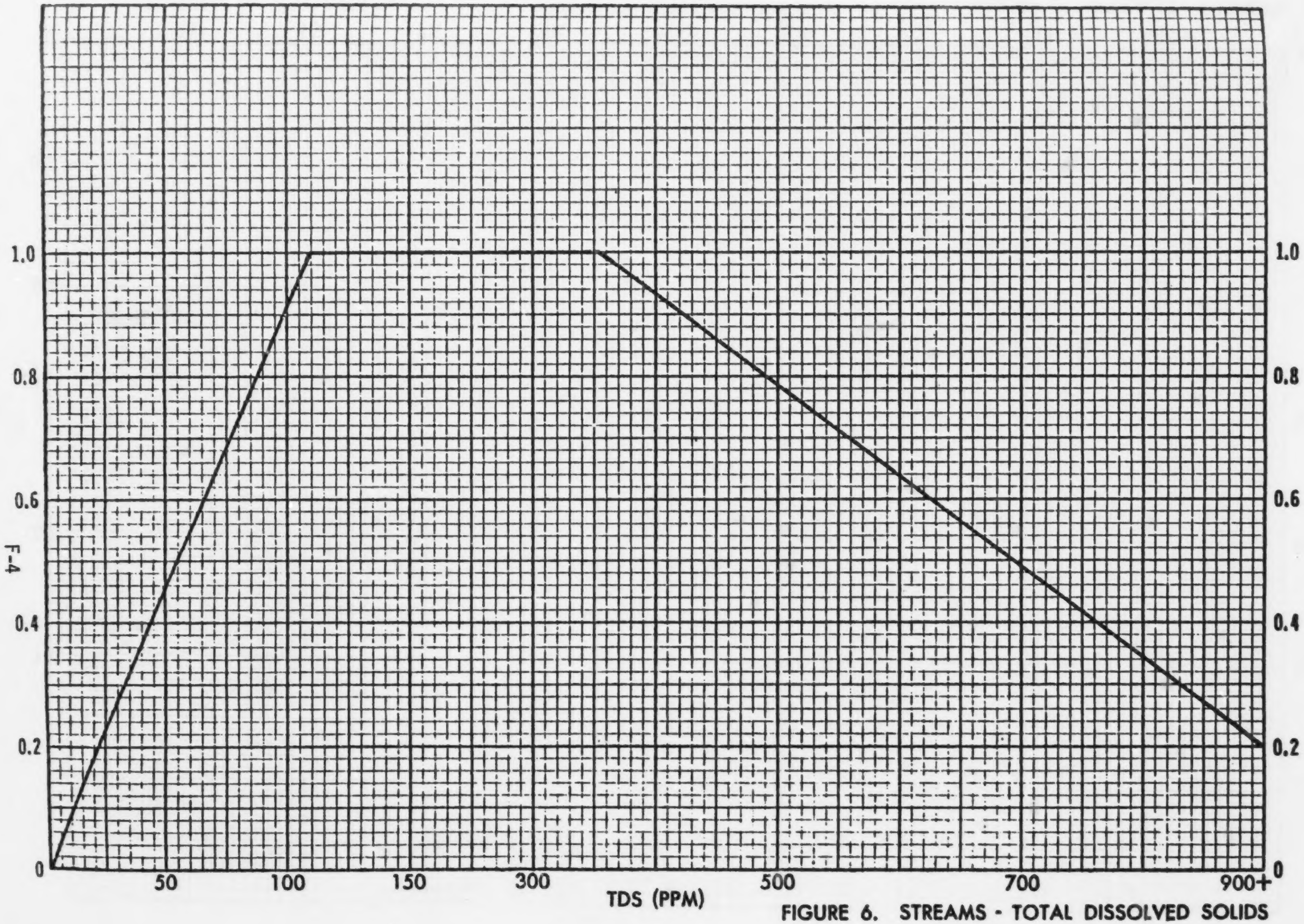


FIGURE 6. STREAMS - TOTAL DISSOLVED SOLIDS

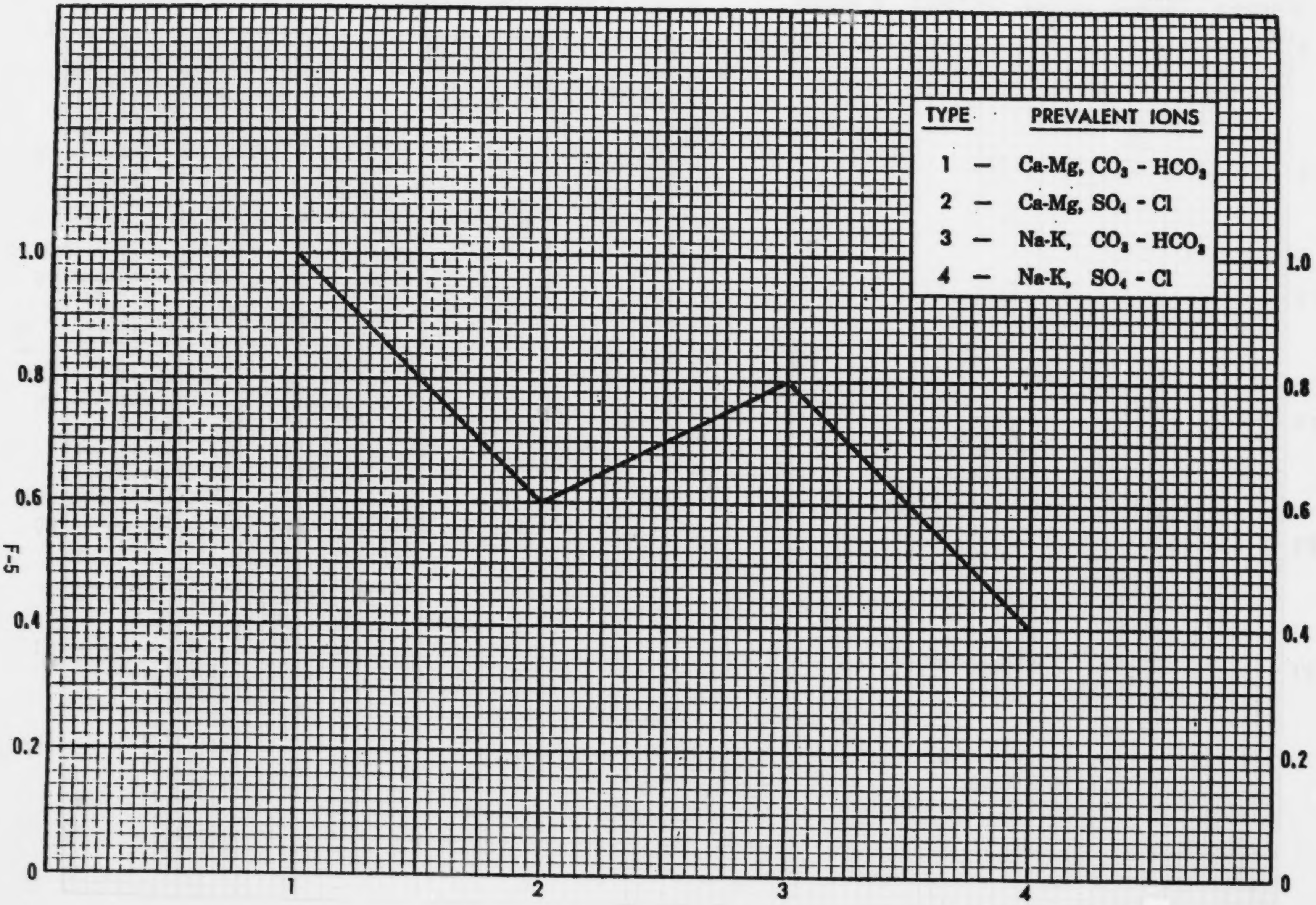


FIGURE 7. STREAMS - CHEMICAL TYPE

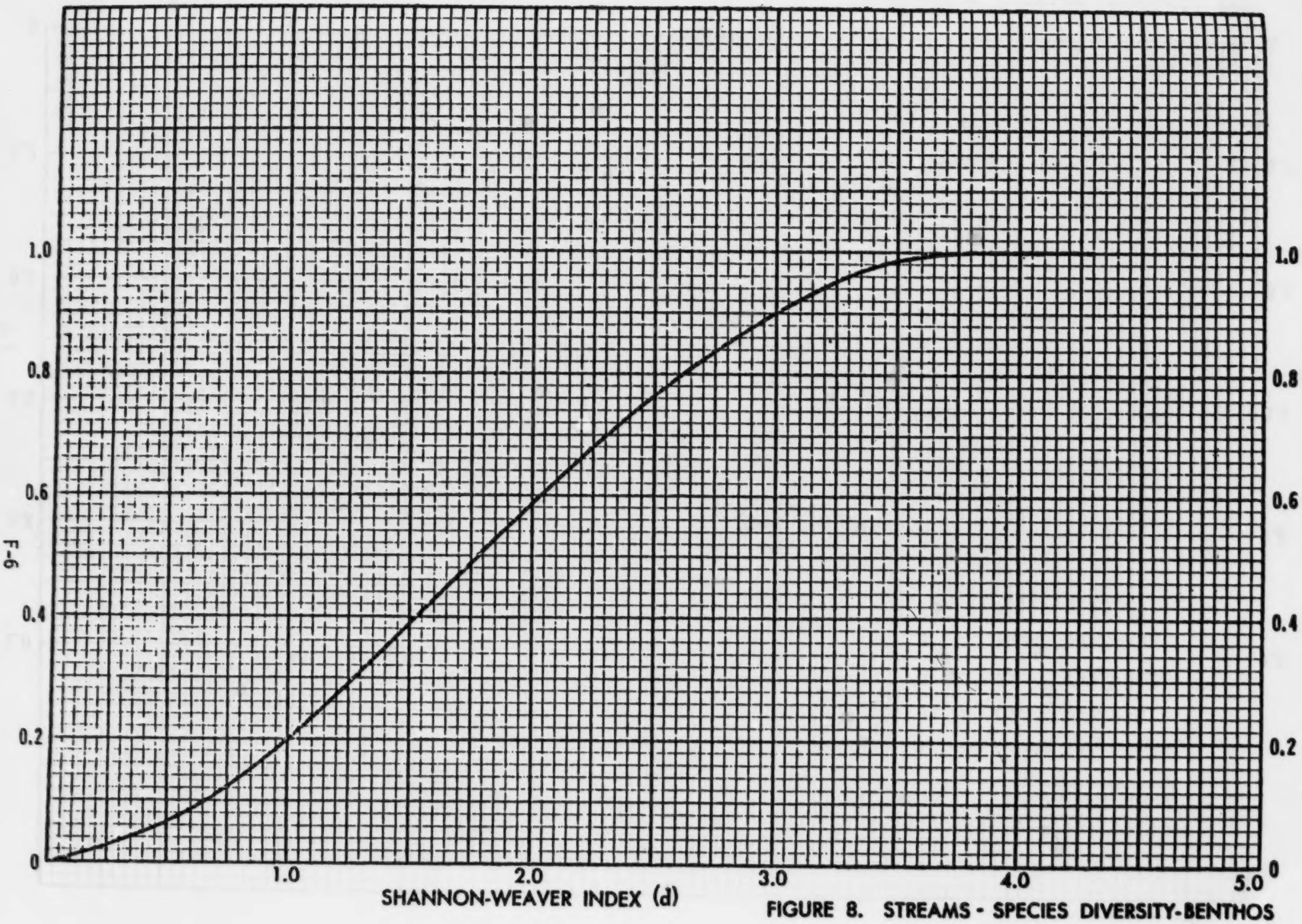


FIGURE 8. STREAMS - SPECIES DIVERSITY-BENTHOS

APPENDIX G

FHWA Method - Selected Forms
(Adamus 1982)

Form A

Functional Opportunity and Effectiveness

The 75 questions in this predictor inventory will ultimately be used to indicate whether there is a high, moderate, or low likelihood of the area (a) having a chance to perform each function, and (b) being effective in performing each. When reading the questions, be sure to review the footnotes located beneath the question and indicated with one or more asterisks. The rationale for each question is explained in the corresponding numbered section of Chapter 3, Volume 1.

If a field visit to the wetland is impossible and no historic field data exist, you may nonetheless conduct an evaluation by answering questions 1 through 21, and possibly a few others which follow, in the office. The resulting estimates will be less accurate. Begin using Form A after first reviewing the instructions on the corresponding form, "Response Sheet A1" (page 51).

A. Office-Type Data

Questions 1-21 below can usually be answered before visiting the wetland.

1. CONTIGUITY. Does channel flow (braided or confined) enter or leave the _____* through a constricted or unconstricted:

   1.1 nontidal inlet?**
   1.2 nontidal outlet?**
   1.3 tidal outlet?
   1.3.1 with a freshwater (tidal or nontidal) inlet present as well?

   GRe, GDe, FSe, SAo, STo, STe, FC, FH, WH, AR, m***

*"_____" as used throughout Form A indicates that the question should first be answered by mentally inserting the term "basin" and circling the Y or N response in the "basin" column of Form A1; and then answered by mentally inserting the term "wetland impact area (WIA)" and circling the response in the "WIA" column of Form A1. For example, the WIA in Figure 3 below has an (unconstricted) outlet but no inlet, whereas the basin has an inlet but no outlet.

**If the basin or WIA is a cove on nontidal water, the entrance to the cove should be considered an "outlet" and "inlet" should be answered affirmatively only if a stream enters the cove from another side.

***These abbreviations, as used throughout Form A, cross-reference the functions for which the question is important, and are as follows: e=effectiveness, o=opportunity, m=mitigation of impact, GR=groundwater recharge, GD=groundwater discharge, SA=shoreline anchoring and dissipation of erosive forces, FS=flood storage and desynchronization, ST=sediment trapping, NR=nutrient retention and removal, FC=food chain support, FH=fishery habitat, WH=wildlife habitat, AR=active recreation.

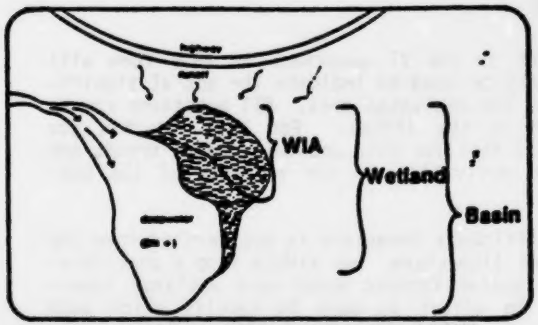


FIGURE 3. ILLUSTRATION OF WIA AND BASIN

2. CONSTRICTION OF BASIN OR WIA.

   2.1 Is the _____'s inlet*:
   2.1.1 lacking or constricted?** (=most basins with predominantly channel flow input of surface water)
   2.1.2 unconstricted?** (=most basins with predominantly sheet flow input of surface water)

   2.2 Is the _____'s outlet*:
   2.2.1 lacking or constricted?** (=most basins with predominantly channel flow output of surface water)
   2.2.2 unconstricted?** (=most basins with predominantly sheet flow output of surface water)

   GRe, GDe, FSe, STe, FC, m

*If basin is connected only tidally, consider the connection on the ocean side to be an outlet.

**As a gross guideline, constricted=less than one-third the maximum width of the _____; unconstricted=greater than two-thirds the maximum width of the _____. Some inlets or outlets may be neither. Measure width in a direction perpendicular to flow.

3. SHAPE OF BASIN.
   Is the basin generally:
   3.1 sinuous or irregularly shaped*, or mostly surrounds a series of islands?
   3.2 rounded or mildly elliptical?**

   GRe, GDe, FSe, STe, FC, FH, WH, m

*If riverine, sinuosity index should be greater than about 1.5, if lacustrine or palustrine, shoreline development index should be greater than about 8.0.

**If riverine, sinuosity index should be less than 1.0; if lacustrine or palustrine, shoreline development index should be less than about 1.5. If desired, a definition of these indices can be found in Volume I, Chapter 3 (p. 53).

4. FETCH and EXPOSURE. (Skip question if greater than 80% of wetland's perimeter abuts open water.) Is the WIA:
   4.1 sheltered from most winds and waves?*
   4.2 unsheltered?*

   SAo, STo, STe, FC, WH, AR, m

*Consider WIA sheltered if: (a) greater than 80% of its perimeter is surrounded by upland or wetland vegetation outside the WIA; or (b) the greatest unobstructed open water distance, drawn as a straight line extending outward from the WIA

Form B

Responses to the 77 questions in this form will ultimately be used to indicate the social significance of the evaluated area. All questions may be answered in the office. For best results, you should be familiar with economic growth trends and planning activities in the vicinity of the wetland.

The significance inventory is not derived from the technical literature, but simply from a consideration of social factors which make wetlands important. No effort is made to specify which such factors are most critical, as this varies greatly among localities. Because the possibilities for social impacts are virtually endless, the questions presented are merely illustrative of the many issues which should be considered in weighing wetlands significance.

Once questions 1 and 2 have been answered, you may be selective in which following groups of questions to answer, depending on which functions are of greatest interest. Begin using this form after first reviewing the instructions on the corresponding form, Response Sheet B1 (page 54). When finished with Forms B and B1 you may turn to Form C (page 46) if you desire impact information, or if not, to section 2.1.2 on page 97.

GENERAL SIGNIFICANCE

1. If the highway were not to be constructed, is the wetland impact area (WIA) within the next 20 years likely to be subjected to any of the following impacts which would result either from other developments, or from essentially permanent or long-term natural processes:

    1.1 filling in, drainage, constriction of flow, or flooding? (e.g., from agricultural drainage, rapid eutrophication, blockage of flow by landslides or dams, flooding by beaver or increased urban runoff, or removal of vegetation by fire, harvest, insects, or larger herbivores).

    1.2 sediment or turbidity increase of more than 10% above normal background levels? (e.g., from increased runoff from naturally or artificially devegetated drainage area, introduction of carp, or geophysical events)

    1.3 extensive channelization? (e.g., for agricultural drainage)

    1.4 extensive paving (more than 5 % increase in paved area?) of subwatershed? (e.g., for residential development)

    1.5 increased exposure to wind and sun? (e.g., resulting from riparian tree mortality due to harvesting, herbivores, fire, etc.)

    1.6. increased disturbance of wildlife and fish? (caused by other development or increased access)

2. Have substantial private or public expenditures been made for the protection, management, or establishment of the WIA? (e.g., previous costs to resource agencies for conservation purchase, seeding, fencing, stocking, fishway installation, water quality improvement, improved access, impoundment, taxes, legal defense, etc.)

SIGNIFICANCE QUESTIONS SPECIFIC TO GROUND WATER RECHARGE

Official Recognition

3. Does the WIA drain directly to or overlay an aquifer presently designated or under consideration by EPA as a "Sole Source Aquifer" under the Clean Water Act?

4. Is the WIA located within or drain directly to, an area mapped, actively managed, or regulated by USGS, state, or local interests as a "potential ground water recharge area"? (or similar terminology).

Uses (Demand)

5. Will any user depend solely on the WIA's aquifer for water supply? (Lacking better data, assume that areas within 3 miles downslope of the wetland will be most dependent on the WIA's contribution to the aquifer.)

6. Will the aquifer be exploited faster by present or future development than it can be replenished? (If specific data lacking, consider whether region generally is expected to have future ground water deficits.)

7. Will future developments which are expected to occur above the wetland basin (with or without the highway) significantly decrease the recharge capacity of these upland areas (e.g., by paving), and consequently increase the relative importance of the wetland basin for recharge?

Relative Contribution (Supply)

8. Is the unaltered WIA's contribution of water to the regional aquifer much more significant* than the recharge contribution from other existing or planned recharge sources (e.g., other wetlands, terrestrial environment)?

*This may be suggested by the following:

--the unaltered WIA will comprise more than 2 % of the functional watershed

--the soils of the functional watershed will have rapid runoff (e.g., steep slopes,

Form C

Responses to the 38 questions in this form will ultimately be used to indicate, very roughly, the probability that the highway project will alter the hydrologic or biological regime of a wetland. Most questions may be answered in the office using basic engineering data for the proposed project, as well as rudimentary field data on the biological communities. The questions are not specific to any wetland function, since almost any highway activity can affect any wetland function. If any question seems irrelevent to the wetland or highway project being considered, skip it. Begin using this form after briefly reviewing Response Sheet C1 (page 54). After completing Form C, turn to Section 2.1.2. (page 56).

A. LOCATION

m1. Will the highway be routed (includes widening of existing routes):

- m1.1 downslope of the basin, on nonwetland soil?
- m1.2 entirely upslope of the basin
- m1.3 within the basin, its tributaries, or outlets?

m2. If upslope of the basin, will the highway be oriented more parallel to the short axis of the wetland than to its long axis? (especially important if wetland circulation or water budget is runoff-dominated).

m3. Will the highway be routed mostly:

- m3.1 parallel and on or tangential to (within 200 ft) the wetland-upland edge?
  - m3.1.1 and wetland circulation and water budget are runoff dominated?
- m3.2 parallel and tangential to (within 200 ft) the wetland-deepwater edge?
  - m3.2.1 and wetland circulation is tidally dominated?
- m3.3 across deep water?
  - m3.3.1 and wetland circulation is dominated by gradient currents or wind?
- m3.4 near the usual windward side of the basin?
  - m3.4.1 and circulation is wind-dominated in the basin?
- m3.5 at or close to the (freshwater) inlet*?
  - m3.5.1 and wetland circulation is dominated by tides or gradient currents?
- m3.6 at or close to the outlet*?
  - m3.6.1 and wetland circulation is dominated by tides or gradient current?
- m3.7 at or close to the tidal outlet?
  - m3.7.1 and circulation is dominated by tides?

*For purposes of this analysis, constricted points in a basin should be considered basin "inlets" or "outlets," and the basin divided by the constriction should be evaluated as two distinct basins. A "constricted point" may arbitrarily be defined as one with a width of less than 30 percent of the mean width of the basin (see Glossary, page 145).

m4. Will the highway cross the basin and its floodplain in a direction more nearly perpendicular than parallel to the major flow whether that flow be directed along- shore, onshore, or offshore, and whether its energy source be runoff, wind, ground water, tide or basin currents?

m5. Will the highway cross the basin at one of its ends or intermediate constricted points?

B. DESIGN AND CONSTRUCTION PRACTICES

m6. Will the basin be crossed:

- m6.1 totally by bridge?
- m6.2 totally by culverted fill?

m7. If the basin will be spanned at least partly by a bridge (if not, don't answer):

- m7.1 Will the bridge be high enough above the water to allow light to enter beneath it?
- m7.2 Will the total cross-sectional area of pilings located within the basin and its floodplain (or within 100 ft upslope from shoreline, whichever is greater) be the minimum necessary to support the structure?
- m7.3 Will pilings be of a streamlined shape relative to the current?
- m7.4 Will the channel be deepened, widened, or selectively cleared to offset the reduction in cross-sectional area unavoidably caused by the pilings?

m8. If the basin needs to be crossed at least partly on fill (if not, don't answer):

- m8.1 Will culverts be of a size, spacing and elevation relative to low flows to adequately assure not only the integrity of the highway, but also to maintain normal water levels, normal flow direction and periodicity, and normal frequency and nearly normal magnitude of flushing and low flows through the wetland?
- m8.2 Will the basin be crossed in such a manner that "mud waves" are unlikely to occur? (e.g., will crossing be at a point where sediments underlying the fill are of a type least likely to buckle and create "mud waves").
- m8.3 Will permeable fill be used?
- m8.4 Will the basin's fill be of the same texture as the substrate?

Response Sheet A1

THRESHOLD ANALYSIS: FUNCTIONAL OPPORTUNITY AND EFFECTIVENESS

This sheet is the appropriate place for recording the responses to corresponding questions in Form A. A "yes" (Y) or "no" (N) response must be circled for all parts of each question, even when the response seems obvious. This response sheet has two major columns--"WIA" and "BASIN", and within each of these, three subcolumns entitled "$\bar{x}$", "W", and "D", which address, when relevent, the seasonal changes in some of the predictors, as follows:

> $\bar{x}$ column responses are those addressing either (a) the average annual condition, or (b) the condition intermediate between the wettest and driest annual conditions (e.g., late June in most Prairie pothole wetlands), or (c) the condition of maximum annual standing crop of wetland plants, or (d) if tidal, the average daily mid-tide condition.
>
> W column responses are those addressing what the area would look like (a) during the wettest time of an average year, or (b) if the area is tidal, what it would look like during an average daily high tide (flooded) condition.
>
> D column responses are those addressing what the area would look like during either the driest time of the year (questions pertaining to hydrology) or if the question pertains to vegetation, then during the dormant time of the year. If the area is tidal, "D" refers to its daily low tide (exposed) condition.

For example, question 2.1.1 should first be asked and answered in the context of the WIA's (wetland impact area's) average condition, then in terms of its wettest condition, then the basin's average condition, and finally the basin's wettest condition. This should then be repeated for question 2.1.2. Because no Y/N choice is given in either "D" column, the area's dry or dormant condition need not be evaluated for this question. Similarly, some questions will require responses only for the WIA or basin, but not both.

	WIA			BASIN		
Q. #	$\bar{x}$	W	D	$\bar{x}$	W	D
Office-type Data						
1.1	Y N	Y N	Y N	Y N	Y N	Y N
1.2	Y N	Y N	Y N	Y N	Y N	Y N
1.3	Y N	Y N	Y N	Y N	Y N	Y N
1.3.1	Y N	Y N	Y N	Y N	Y N	Y N
2.1.1	Y N	Y N		Y N	Y N	
2.1.2	Y N	Y N		Y N	Y N	
2.2.1	Y N	Y N		Y N	Y N	
2.2.2	Y N	Y N		Y N	Y N	

	WIA			BASIN		
Q. #	$\bar{x}$	W	D	$\bar{x}$	W	D
3.1					Y N	
3.2					Y N	
4.1	Y N					
4.2	Y N					
5.1					Y N	
5.2					Y N	
6.1		Y N				
6.2		Y N				
7.1				Y N		
7.2				Y N		
8.1					Y N	
8.2					Y N	
9.1				Y N		
9.2				Y N		
10.1	Y N					
10.2	Y N					
10.3	Y N					
10.4	Y N					
11.1	Y N					
11.2	Y N					
12.1		Y N				
12.2		Y N				
13.1				Y N		
13.2				Y N		
14.	Y N			Y N		
15.1	Y N					
15.2	Y N					
15.3	Y N					
15.4	Y N					
15.5	Y N					
15.6	Y N					
15.7	Y N					
16.	Y N					
17.1	Y N					
17.2	Y N					
18.	Y N					
19.	Y N					
20.				Y N		
21.1	Y N					
21.2	Y N					
21.3	Y N					
21.4	Y N					
21.5	Y N					
21.6	Y N					
Field-type Data						
22.1	Y N	Y N		Y N	Y N	
22.1.1	Y N	Y N		Y N	Y N	
22.1.2	Y N	Y N		Y N	Y N	
22.1.3	Y N	Y N		Y N	Y N	
22.1.4	Y N	Y N		Y N	Y N	
22.1.5	Y N	Y N		Y N	Y N	
22.2	Y N	Y N		Y N	Y N	
22.2.1	Y N	Y N		Y N	Y N	
22.2.2	Y N	Y N		Y N	Y N	
22.2.3	Y N	Y N		Y N	Y N	
22.2.4	Y N	Y N		Y N	Y N	
22.2.5	Y N	Y N		Y N	Y N	
22.3	Y N	Y N		Y N	Y N	
22.3.1	Y N	Y N		Y N	Y N	
22.3.2	Y N	Y N		Y N	Y N	
22.3.3	Y N	Y N		Y N	Y N	
22.3.4	Y N	Y N		Y N	Y N	
22.4	Y N	Y N		Y N	Y N	
22.4.1	Y N	Y N		Y N	Y N	
22.4.2	Y N	Y N		Y N	Y N	
22.5	Y N	Y N		Y N	Y N	
22.6	Y N	Y N		Y N	Y N	

Response Sheet B1

THRESHOLD ANALYSIS: SIGNIFICANCE

This sheet is the appropriate place for recording the responses to the corresponding questions in Form B. Circle Y (yes) or N (no), being careful to note that the order of Y and N below frequently reverses.

General
1.1 N Y
1.2 N Y
1.3 N Y
1.4 N Y
1.5 N Y
1.6 N Y
2. Y N

Recharge
3. Y N
4. Y N
5. Y N
6. Y N
7. Y N
8. Y N
9. Y N
10. N Y

Discharge
11. Y N
12. Y N
13. Y N
14. Y N
15. N Y

Flood Storage
16. Y N
17. Y N
18. Y N
19. Y N
20. Y N
21. Y N
22. N Y

Shoreline Anchoring
23. Y N
24. Y N
25. Y N
26. Y N
27. Y N
28. Y N
29. N Y

Sediment Trapping
30. Y N
31. Y N
32. Y N
33. Y N
34. Y N
35. Y N
36. N Y

Nutrient Retention
37. Y N
38. Y N
39. Y N
40. Y N
41. Y N
42. N Y

Fish Food Chain/Habitat
43. Y N
44. Y N
45. Y N
46. Y N
47. Y N
48. Y N
49. Y N
50. Y N
51. Y N
52. Y N
53. N Y

Wildlife Habitat
54. Y N
55. Y N
56. Y N
57. Y N
58. Y N
59. Y N
60. N Y

Active Recreation
61. Y N
62. Y N
63. Y N
64. Y N
65. Y N
66. Y N
67. N Y

Passive
68. Y N
69. Y N
70. Y N
71. Y N
72. Y N
73. Y N
74. Y N
75. Y N
76. Y N
77. Y N
78. N Y

Next, turn to Form C (page 46).

Response Sheet C1

THRESHOLD ANALYSIS: IMPACT VECTOR

This sheet is the appropriate place for recording the responses to the corresponding questions in Form C. Circle Y (yes) or N (no).

m1.1 Y N
m1.2 Y N
m1.3 Y N
m2. Y N
m3.1 Y N
m3.1.1 Y N
m3.2 Y N
m3.2.1 Y N
m3.3 Y N
m3.3.1 Y N
m3.4 Y N
m3.4.1 Y N
m3.5 Y N
m3.5.1 Y N
m3.6 Y N
m3.6.1 Y N
m3.7 Y N
m3.7.1 Y N
m4. Y N
m5. Y N
m6.1 Y N
m6.2 Y N
m7.1 Y N
m7.2 Y N
m7.3 Y N
m7.4 Y N
m8.1 Y N
m8.2 Y N
m8.3 Y N
m8.4 Y N
m9. Y N
m10.1 Y N
m10.2 Y N
m11. Y N
m12.1 Y N
m12.2 Y N
m13. Y N
m14. Y N
m15. Y N
m16. Y N
m17. Y N
m18. Y N
m19. Y N
m20. Y N
m21. Y N
m22. Y N
m23. Y N
m24. Y N
m25. Y N
m26.1 Y N
m26.2 Y N
m27. Y N
m28. Y N
m29. Y N
m30. Y N
m31. Y N
m32. Y N
m33. Y N
m34. Y N
m35. Y N
m36. Y N
m37. Y N
m38. Y N

Turn to Section 2.1.2 after completing this form (see p. 56).

Summary Sheet D

This form is the appropriate place for recording the ratings that result from use of the interpretation procedures and keys in Sections 2.1.2, and 2.2.2. As each analysis is completed, enter its rating (high,moderate, or low; or A, B, or C) in the relevant box until all boxes for functions of interest are filled.

Begin by labeling the context of the analysis (pre- or post- construction, with or without mitigation, name of basin and WIA). Then enter the data, using the numbered footnotes to help locate the associated analyses. For the evaluation of each function's Effectiveness, enter whichever rating is higher--That for the basin or that for the WIA. The evaluation of the impact vector is optional.

BASIN____________________ WIA ____________________ PROJECT _______________

EVALUATION TIME FRAME (PRE/POST) ____________________ MITIGATION PLAN # _______________

FUNCTION	EFFECTIVENESS[1]	OPPORTUNITY[1]	FUNCTIONAL RATING[2]	SIGNIFICANCE[3]	FUNCTIONAL SIGNIFICANCE[4]
GROUND WATER RECHARGE[5]					
GROUND WATER DISCHARGE[6]		▨			
FLOOD STORAGE[7]					
SHORELINE ANCHORING[8]					
SEDIMENT TRAPPING[9]					
NUTRIENT RETENTION LONG-TERM[10] SEASONAL[11]					
FOOD CHAIN SUPPORT DOWNSTREAM[12] IN-BASIN[13]					
FISHERY HABITAT WARMWATER[14] COLDWATER[14] COLDW.RIVERINE[14] ANADROMOUS RIV. SPECIES[15] __________					
WILDLIFE HABITAT GENERAL DIVERSITY[16] WATERFOWL GP.[17] WATERFOWL GP.[17] SPECIES[18] __________ SPECIES[18] __________ SPECIES[18] __________					
ACTIVE RECREATION[19] SWIMMING BOAT LAUNCHING POWER BOATING CANOEING SAILING					
PASSIVE RECREATION AND HERITAGE[20]	▨	▨	▨		
IMPACT VECTOR RATING[21]					

FOOTNOTES

These entries will be based on analyses in the following parts of Volume II (numbers correspond to footnotes above):

[1] Forms A, A1 (p. 6, 51); [2] Section 2.1.2.2. (p. 97); [3] Forms B, B1 (p. 38, 54); [4] Section 2.1.2.2. (p. 97); [5] Interpretation key in Section 2.1.2.1. p. 57; [6] p. 59; [7] p. 60; [8] p. 62; [9] p. 64; [10] p. 67; [11] p. 67; [12] p. 69; [13] p. 71; [14] p. 73; [15] p. 75; [16] p. 79; [17] p. 80; [18] p. 84; [19] p. 91; [20] p. 92; [21] p. 93.

Ground Water Discharge Key

a. Effectiveness per unit area for discharge

The probability that ground water discharged to the basin or wetland exceeds recharge (deep or shallow) to the ground water on a net annual basis is:

potentially HIGH if: A + (B or C(1,2,3,4)) below*

*For the discharge function, use only the information in the X̄ column of Response Sheet A1; if this is lacking, use information in the "W" column or (least priority) "D" column.

	(office data)	(field visit data)	(detailed data)	Summary Description
A. either		(26.1Y/.9Y/.10Y)	56 N or	piezometric measurements (no recharge), permanently flooded.
+				
B. most of the following		39.3Y,	61.1Y,62Y	dam upstream, chemical and thermal indicators of discharge
OR				
C. most of the following:				
1. any of the following	2.2.2Y,	32.1N, 41.4N		unconstricted outlet, flows removed quickly, basin not densely vegetated.
2. plus	(1.2Y or 1.3Y),			outlet present
+				
3. any of the following	9.2Y,12.1Y,	29N,	65Y	low in watershed, steep subwatershed, very stable flow or water level, porous underlying strata
+				
4. most of the following	(3.1Y + 5.2Y), 18Y,	(23.8N or 32.5Y)		lithologically diverse subwatershed, not silty

potentially LOW if: I or II (A , B , C , D , E) below

	(office data)	(field visit data)	(detailed data)	Summary Description
I.			56Y	recharge measured high
OR				
II. most of the following				
A.	1.2N			no outlet
B.	(2.2.1Y or	32.1Y or 41.4Y)		flows not rapidly removed
C.			65N	no porous underlying strata
D.	9.1Y			high in watershed
E. most of the following	(3.1N+5.1Y), 18N	(23.8Y or 32.1Y)		not lithologically diverse silty

potentially MODERATE if rated neither HIGH nor LOW above.

b. Opportunity per unit area for discharge: Opportunity for discharge cannot be predicted without very extensive geologic data.

Harvested Waterfowl: Breeding Habitat Key

Group	Conditions	(office data)	(field visit data)	(detailed data)	Summary Description
Group 1	all the following	15.1N,	22.1N, 41.2Y, 44.2N, 34.1N, 34.4N,		not forested; interspersed shallow
	plus most of the following	(1.1N + 1.2N), 6.2Y, 10.1N,	50Y, 49.2Y, 44.1Y,	58.2Y	productive food base not low order; interspersed
		(15.4Y or .7Y),	39.6N,		unforested upland, not farmed
			(26.3Y/.4Y/.6Y), 29N, (23.3Y/.4Y), 37Y		not permanently flooded or flashy emergent, island
Group 2:	all the following	- -	41.4N, 49.1N, 34.1N, 34.4N,		shallow, juxtaposed,
(black duck, wood duck)	plus most of the following	(15.1Y or .2Y),	50Y (22.1Y/.2Y), 37Y, (41.1Y/.2Y), 44.2N, (26.1Y/.2Y/.8Y),	51.2N, 58.2N	productive food base forested/scrub, isolated interspersed permanently flooded basin
		(1.1Y or 1.2Y),	29N (black only)		contiguous, not flashy
Group 3: (mergansers)	all the following	5.1N, 10.1N, (15.1Y or .2Y),	34.1Y, 26.1Y, (41.1Y/.2Y),		not small; forested, deep permanently flooded, open
	plus two of the following	(1.1Y or 1.2Y), 5.2Y, 9.2N,	37Y, 29N (except hooded)		continuous, large island not low in watershed or flashy
Group 4: (goldeneye,	all the following	(15.1Y or .2Y or	22.1Y or .5Y), 41.4N, (26.1Y/.2Y/.8Y), 34.3Y		forested or moss permanently flooded
ring-neck)		10.1N,	34.3Y, 49.1N		juxtaposed, deep, not low order
	plus three of the following	(1.1Y or 1.2Y),	41.2Y, 44.1Y, 49.2Y,	53Y,	contiguous, juxtaposed, interspersed
		6.1N,	37Y		island, not small or flashy
Groups 5 & 6:	all the following	5.1N, 15.1N,	22.1N, 34.3Y 41.2Y		not small or forested; interspersed, deep
(prairie divers)	plus most of the following	(1.1N +1.2N),6.2Y,		58.2Y	food base productivity
		5.2Y, 10.1N,	44.1Y, 49.2Y,		large, not low order; interspersed
		(15.4Y or .7Y),	39.6N,		unforested upland, not farmed
			(26.3Y/.4Y), 29N, (22.3Y/.4Y), 37.Y 50Y (group 5 only) or	53.2Y (group 6 only)	not permanently flooded or flashy emergent/aquatic bed isolated plant species desirable invertebrates not scarce
Group 7: (Canada goose)	all the following	(15.4Y or 15.7Y), 5.1N,	22.1N, 41.4N, (26.1Y/.2Y/.8Y), 34.3Y,		not forested; open water not small or shallow; permanently flooded not 1st order stream
	plus most of following	10.1N, (1.1Y +1.2Y), 3.1Y (9.2Y or 10.3Y),	(22.3Y/.4Y). 41.2Y, 44.1Y. 49.1Y, 49.2.2Y 29N, 37Y, 50Y		slow riverine, emergent aquatic bed, interspersion island, food, not flashy
Group 9:	all the following	15.4Y,	(26.3Y/.4Y/.6Y/.8Y),		farmland, not permanently flooded.
(whistling ducks)			34.4N, 50Y		not deep preferred foods

Impact Vector Key

Unlike the keys for wetland functions, the impact key is not substantially derived from technical literature. This is because the number of published articles dealing with ecological impacts of highways, and in particular the highway-related or natural factors which mitigate or aggravate highway impacts, is too small. Only for sediment transport has research been sufficient to allow development of quantitative predictive models. Results of the few available ecological research studies are presented in Tables 19 and 20 of Volume I.

Thus, the impact key is almost entirely relative, with the "low impact" condition serving as a benchmark and consisting of the best circumstances possible for a highway-wetland interaction. Although this presents an extraordinarily difficult standard to achieve, the consequences of not meeting it are minor in terms of the overall procedure, since the impact vector rating is merely advisory. For example, only highways which (a) are downslope from wetlands, or (b) are upslope and are very well designed, or (c) cross wetlands entirely on tall pilings (bridges), receive a rating of LOW impact, and then only if the wetland is of a type which is not highly sensitive. A rating of HIGH impact is automatically assigned if the wetland is crossed entirely on fill, regardless of whether it is adequately culverted and optimally located. Projects involving widening of existing roads are considered equally with projects involving new rights-of-way, although their ultimate ratings may differ.

The major purpose of the key is to focus attention on factors which might mitigate highway-wetland impacts. These factors fall under the following categories: design, location, erosion and transport of sediment to wetland, sediment export from wetland, inherent sensitivity of vegetation and fish, vegetation and fish community's adaptedness to stress, vegetation and fish recovery capacity, and presence of multiple stresses to vegetation and fish. All are discussed in Chapter 5 of Volume 1.

The probability that highway construction will result in measurable long term alteration (either adverse or beneficial)of the wetland's hydrologic or biological environment over an area at least double that occupied by the right-of-way is:

potentially LOW if: I or II (A1-3 + B1-5 + C1-3) or III (A1-3 + B + C + D)*

*Numbers below with the prefix "m" refer to responses on Response Sheet C1 (page 54); other numbers refer to responses on Response Sheet A1 (page 51). For the other numbers, use only the information in the column of Response Sheet A1 which corresponds to the expected season of construction (W=wet, D=dry, x̄=intermediate). Also, for the underlined responses, use only the "WIA" responses from Response Sheet A1 to arrive at a rating for the WIA, recording it at the bottom of Summary Sheet D (page 55).

	(office data)	(field visit data)	(detailed data)	Summary Description
I. Route is entirely downslope from basin and:				
All of the following	m1.1Y,m3.7N, m11.1N,11.1N			downslope, not near outlet, no temporary diversions, gradient not gradual
OR				
II. Route is entirely upslope from basin and:				
IIA. All of the following (1+2+3) below:				
(1.) All of the following	m3.1N, m11N,m13N, m14N,m15.1Y, m16Y,m17N, m18N,m20N			location=not parallel and tangential to upland edge, design=no flow diversions, equipment out of wetland, good sediment control, revegetation, buffer strip, minimize bare earth seasonal scheduling, wetland not used for storm water (=good mitigation of primary runoff factors)

Impact Vector Key (continued)

(2.)plus	11.2Y or 17.1N			gently sloped subwatershed soils not highly erodible
				(=erosion + transport: primary factors that reduce loading)
(3.)plus	m2Y,11.2Y,			parallels short axis, gently sloping subwatershed,
most*	12.1Y,17.1N,	39.1N,		tribs. gently sloped, not channelized, impervious soils,
		40Y		pool-riffle ratio good upstream,
			54.1N,66.2Y,	not scavenging sediment, impervious soils, (=erosion + transport: secondary factors that reduce loading)
*Ignore this series if basin has no inlet.				
IIB. Plus all of the following:				
(1) all	(1.2Y/.3Y),	32.1N,		outlet, not stagnant, not anoxic
			m23N	flushing consequences minor downstream
(2) either		22.3N or (22.3Y +		not aquatic bed or if so,
			m24Y),	species are sediment-tolerant,
(3)			57.1N,	plant "adaptedness" (TSS not low),
			59.1N,59.2N,	nutrients not too great or little,
			m29Y	no response to analogous alteration,
(4)most of the following	2.2.1N,	23.8N,29Y,		unconstricted outlet, substrate coarse, flashy,
	3.1N,	30.2Y,		basin not sinuous, big tidal range,
	4.1N,8.1Y,	31.2Y		unsheltered, big subwatershed, scoured,
	10.3Y,13.1N,	43N,		large stream order, steep basin, not sheet flow,
	(21.1N/.2N),	45.1Y,	57.2N,	not lacustrine/palustrine, steep edge, not turbid,
			67.1N,"75.1N"	output exceeds input, not a sediment trap (=sediment export: secondary factors that reduce loading)
(5)most of the following			m24Y,m25N,	plants are sediment-tolerant, not near depth (light) threshold,
			m26.1Y,	plants are not flood-sensitive,
		26.1Y,29Y,		permanently flooded, flashy,
		49.2Y,52.1N,59.1N,		diverse plant forms, not oligotrophic,
			"75.1Y"	sediments accumulate
				(=good plant recovery capacity/adaptedness to stress),
		(24.1Y or 24.5Y)		salinity not stressing,
			"72.1Y"	erosion not stressing (=lessened multiple stresses)
IIC. Plus all of the following (answer only if impact on freshwater fish needs to be determined).				
(1) most of the following			m30Y,m31N,	fish sediment-tolerant, not geographically peripheral,
			m32N,	fish do not require currents, (=fish not inherently sensitive)
		23.8Y,		substrate is mud/organic,
		32.1Y,		stagnant,
		(36N or	64N),	anoxic sediments,
		28.1Y,29Y,	"75.1Y"	flashy basin, basin is sediment trap,
			m34Y	historical resistance to stress, (=fish may be "adapted" to stress)

Impact Vector Key (continued)

(2)plus all of the following	(1.1Y/.2Y/.3Y), 10.1N,	26.1Y,		basin has outlet or inlet, not a headwater stream, basin permanently flooded,
		39.5N,	m38,	no barriers to fish movement, stocking conducted,
			60.1N	no fish kills (=good recolonization potential: primary factors)
(3)plus most of the following	5.2Y,9.2Y, 10.3Y,	40.2Y,		large basin, low in watershed, stream order is 4+, good pool-riffle ratio, (=good recolonization, potential: secondary factors)
		36Y,	64Y,	no anoxia problems,
		46.1N,	60.2N,60.3N,	no algal blooms, no ice cover, not unshaded,
			m35N m36Y,m37N,	depth distribution will change little, fish not near salinity or temperaure thresh. (=lessened multiple stress)

-OR

III. One part of route is upslope from basin, and another part crosses it entirely by bridge (i.e., no fill used within basin or floodplain) and: A (1+2+3) + B + C + D

A(1)all of the following	m7.2Y,m11N or (m12.1+2Y)		fewest possible pilings, minimal flow diversions during construction, equipment kept out of wetland (=good primary design factors)
+			
(2)none of the following		m3.1.1Y,	if runoff-dominated, route not tangential to upland edge
		m3.2.1Y,	if tidal, not tangential to open water edge
		m3.4.1Y,	if wind dominated, not on windy side
		m3.5.1Y,m3.6.1Y,	if current-dominated, not near inlet or outle
		m3.7.1Y,	if tides dominate, not near pass (=minimize flow regime interference)
+			
(3)most of the following	m4N,m5N,		highway routing parallels flow, no crossing at constriction,
	m7.1Y,m7.3Y, m7.4Y,m12.1Y,		minimal shading, streamlined pilings, cross-sec. area maintained, minimal flow diversion
	m12.2Y		(=minimal flow and light interference)
+			

B.+ conditions in Part IIB above are met
C.+ conditions in Part IIC above are met (if knowledge of impact on freshwater fish is desired)
D.+ conditions in Part IIA above are met

potentially MODERATE if: I or II(A or B) or III (A or (B + C)) or IV (A + B + C (1-3)) below

I. Route is entirely downslope from basin and:11.2Y (=downslope gradient is gradual).

-OR

II. Route is entirely upslope from basin and:
A. conditions in Part IIA above are met

Impact Vector Key (continued)

OR

B. conditions in Part IIB and (if knowledge of impact on freshwater fish is desired) conditions in IIC are met

OR

III. Route is both upslope from wetland and crosses it entirely by bridge and: (A or B) + C below)

A. conditions in Part IIA above are met

OR

B. conditions in Part IIB and (if knowledge of freshwater fish impact is desired) conditions in IIC above are met

+

C. conditions in Part IIIA above are met

OR

IV. Route is both upslope from wetland and crosses it by a combination of bridge and fill (in any ratio) and: (A + B + C below)

All of the following:

A. conditions in Part IIA above are met

+

B. conditions in Part IIB and (if knowledge of impact on fish is desired) IIC above are met

+

C. All of the following:

(1) all of the following:

m8.1Y,m8.2Y, m9N,(m11Nor m11Y+m12.1Y, m12.2Y),m13N,	adequate culverting, no mud waves, no access canals, minimize damage from channel diversion, equipment kept out of wetland

+

(2) most of the following:

m7.1Y,m7.3Y, m8.3Y,m8.4	fill design: secondary factors

(3) none of the following:

m3.1.1Y,	if runoff-dominated, highway tangential to upland edge,
m3.2.1Y,	if tidal, tangential to open water edge,
m3.4.1Y,	if wind-dominated, not on windy side,
m3.5.1Y,	if currents dominate, not near inlet or outlet
m3.7.1Y	if tides dominate, near pass

potentially HIGH impact if:

I. Wetland or flood plain is crossed entirely on fill

OR

II. Probability of wetland impact is rated neither LOW nor MODERATE above

APPENDIX H

QUANTITATIVE METHODS FOR DETERMINING WETLAND VALUES
(from Ludwig and Apfelbaum unpublished).

Table Methods of measuring, categorizing, and valuing of wetland resources.

Plant Diversity

By thorough species inventory work, determine the presence and dominance of species in the plant communities. Wetlands should be mapped under the dominant species concept of Whittaker (1975), and species richness measured two ways--as mean diversity per sampled quadrat and as total species found in the wetland. These diversity numbers and species are to be referenced against the *total number of species possible* in the particular wetland as determined by literature search or competent botanists knowledgeable about the particular wetlands under study. Numerical Score: 1 to +30.

Plant Productivity

By measuring the annual rate of primary production in the wetland as grams of carbon fixed per square meter per year, the actual primary production of the wetland community can be measured against other wetlands, drylands, and agricultural lands, and the projected impact of the proposed use assessed. If possible, the four most significant primary producers should be measured independently. Numerical Score: 1 to +20. Primary production less than 500g/m^2/y^{-1} should be scored +1. Production at or above 3000/m^2/y^{-1} scored +20.

Plant Communities

Determine the size, extent and spatial distribution of the plant communities by careful mapping. Wetlands with a single plant community should be rated +1, with 10 or more distinct communities rated +20. Follow the methods of Whittaker (1975) in determination of community type. Changes in plant communities can be monitored over a long period to measure ecosystem changes.

Animal Diversity

By a thorough inventory of all vertebrates and the most important invertebrates using the area, the animal species richness should be measured. Emphasis should be placed on aquatic (associated) species, such as molluscs, fish, amphibians, rails, beavers, etc. Standard methods such as fish seining or shocking, mammal trapping on grid, a breeding bird census, etc., should be used. Numerical Score: 1 to +30. In order to score highly, species diversity should be high in all taxa.

Table Methods of measuring, categorizing, and
valuing of wetland resources (concluded).

E. Animal Productivity

For each animal species *breeding* in the wetland, the size of the population on a number per hectare basis should be estimated. Emphasis should be placed on such species that must use the wetland for reproduction, e.g., smallmouth bass, sora rail, beaver, although all breeding species should be estimated. These estimates should be referenced to other wetland areas and tothe bodies of water to which aquatic species move (Example: Marshland raised fish moving to a lake for adult life.). Numerical Score: 0 to +20. To score highly, the wetland should have high local and regional significance.

F. Migratory Species Habitat and Cover Provided to Local Non-Wetland Requiring Species

Many animals use certain wetlands casually for cover, (e.g., deer), may—but do not have to—breed there, (e.g., Red-winged Blackbird), or as a migratory stop-over (e.g., Sandhill Cranes). The importance of the particular wetland for the welfare of these species should be measured by *systematic* observations. Mark-recapture studies may be needed to separate some resident from transient species. Numerical Score: 1 to +15, partly subjective. To score highly the wetland should provide a significant volume of habitat for these species.

G. Rare, Threatened and Endangered Species

The preservation of these species is required under Michigan and Federal law. The presence of an *endangered* species can stop any proposal to use wetlands. The presence of rare or threatened species may require special studies or efforts to transplant and reestablish potentially impacted species elsewhere. *Credit* for providing habitat for such fragile species should be given to proposals if such mitigation is possible. Numerical Score: 1 to +30. One or more endangered species = +30; +15 for each threatened species present; +5 for each rare species present.

H. Critical Habitat(s) Ratings

Some wetland types are abundant locally, but rare statewide. Essential habitat for certain species (e.g., Double-crested Cormorant, Forester's Tern) may be common locally (e.g., Great Lakes islands), but exceedingly rare statewide. *This critical habitat and potential critical habitat* should be referenced to rare, threatened and endangered species on a statewide basis. Potential critical habitat development for these species should be credited to the proposed development if an applicant can demonstrate this to be a likely result of implementing the proposed development. Numerical Score: 1 to +20.

I. Ecosystem Wholeness Rating

Few surviving wetlands support the full complement of plants and animals that they once did. Others are widely invaded by a Eurasian flora which has altered their character. This rating is a partly subjective rating developed by a qualified ecologist from parameters A-G (above) on the biological completeness and stability of the specific wetland in question: This is the holistic judgment of the ecosystem's completeness and overall health in its present condition, under present trends of use and protection. Numerical Score: 1 to +20.

Table Summary of biological parameters weighting system.

	Minimum Score	Maximum Score
Plant Diversity	+ 1	+30
Plant Productivity	+ 1	+20
Plant Communities	+ 1	+20
Animal Diversity	+ 1	+30
Animal Productivity	+ 1	+20
Migratory & Local Species Cover Habitats	+ 1	+15
Rare, Threatened & Endangered Species	+ 1	+30
Critical Habitat(s) Ratings	+ 1	+20
Ecosystem Wholeness Rating	+ 1	+20
Total Range of Scores	+ 9	+205

Table Hydrological parameters.

A. Physical and Configurational Attributes

1. Flood Amelioration Function

Determine the *specific* flood control role and function of the wetland in question.[a] Determine the temporal storage capacities together with effects on downstream watersheds and discharge volumes (NOTE: Such estimates are often required in permit applications as part of Flood Plain Zoning or delineation.). Numerical Rating: 1 to +20. Give the wetland a rating of +20 if it can store 50% or more of a 10-year flood in its watershed for 24 hours, or a proportionately lower score to +1 as this capacity decreases to 1% of 10-year flood.

2. Sediment Trap Function

Through field measurements of total suspended solids or turbidity, estimate the annual sediment load input and output of the specific wetland in question. Relate these data to upstream watershed size and estimate importance of specific wetland as sediment trap. If >75% of sediment load is captured give the wetland a perfect score of +20, scaling the score downward to 0 if no sediment trap function is measurable.

3. Surface Water Storage Function

Measure the normal capacity of the wetland to store surface water as acre foot per acre of wetland surface. Determine normal rates of evapotranspiration on a seasonal basis to determine effects on downstream watershed flows if any. Measure this function against the size of the upstream watershed. If 75% of water provided by the upstream watershed is stored less evapotranspiration, give the wetland a rating of +15 with a proportionately lower score down to +1 to 5% or less water storage capacity less evapotranspiration with reference to the upstream watershed.

4. Groundwater Recharge Function

Determine the areal extent of the wetland. Measure its function as a recharge area for the uppermost aquifer through determination of its capacity to infiltrate waters from the upstream watershed into the first subsurface aquifer. Measure by means of soil permeabilities above the first clay or fragiopan layer immediately below the wetland's own bottom seal. Relate this recharge rate to the amount of water available for infiltration from the upstream watershed. If 10% of annual watershed volume infiltrates in wetland, rate at +20, less so as groundwater recharge function decreases to zero with reference to the watershed.

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[a] An example of an accepted standardized manual for such estimates is Conger (1971), "Estimating Magnitude and Frequency of Floods in Wisconsin", which is applicable in Wisconsin.

Table Hydrological parameters (continued).

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[a] An example of an accepted standardized manual for such estimates is Conger (1971), "Estimating Magnitude and Frequency of Floods in Wisconsin", which is applicable in Wisconsin.

Table Hydrological parameters (concluded).

5. Biomass Sink and Storage Function

Normally wetlands accumulate organic matter due to higher primary production than export and decomposition. Accumulated organic peats have important effects on water storage volumes and influence water quality treatment or degradation of output waters. Measure the rate of accumulation by coring the sediments; measure the organic matter content water holding capacity and classify the peats/soils with standard sapric-humic soils methods. If peats-organics are present in a *volume >50%* of the water volume stored, rate as +10, less so if lesser amounts of organics are found.

6. Watershed Importance Rating

Determine the size of the wetland and its upstream watershed; if the sum of both is greater than 5000 hectares, rate at +25; if of lesser size, down to 100 hectares, rate downward to +1 in proportion to the 5000 hectares standard. This arbitrary size-dependent rating which includes the upstream watershed insures that river and most lake margin marsh lands receive higher ratings than small perched water-table wetlands.

3. Physio-Chemical Attributes

1. Water Quality Functions

Measure the standard parameters of bacteria, BOD/COD, nutrients, pH, heavy metals, TDS, TSS of inlet and outlet water seasonally at peak, normal and low flow periods. Rate improvement or lowering of water quality on an annual basis with a -20 to +20 scale paying greatest attention to nutrients, heavy metals and oxygen demand. Numerical Rating: -20 to +20. NOTE: This is a measure of the potential for cost-free natural water treatment service. If the absolute value of this potential service ≥ $2,000/hectare/year, rate as +20, with lesser ratings assigned to lesser dollar values downward to -20 for water quality degradation equal to a cost of $2,000/hectare/year if the water were treated to bring it up to EPA standards.

2. Cation Exchange and Storage Capacities

Measure wetland cation exchange capacity, ion storage capacity, buffer capacity and adsorption-chelation capacities under both aerobic and anaerobic conditions. *Determine the loading factors (capacities) that the wetland can absorb without significant loss of its essential biological functions.* Numerical Rating: 1 to +20. Measure against the size of the upstream watershed and its water quality. NOTE: This is a measure of the potential for cost-free natural water treatment service. If the absolute value of this potential service ≥ $2,000/hectare/year, rate as +20, with lesser ratings assigned to lesser dollar values downward to +1 for no measurable exchange function.

Table Summary of hydrological weighting system parameters.

Functional Category	Minimum Score	Maximum Score
Flood Amelioration	+ 1	+ 20
Sediment Trap	0	+ 20
Surface Water Storage	+ 1	+ 15
Groundwater Recharge	+ 1	+ 20
Biomass Storage	+ 1	+ 10
Watershed Importance	+ 1	+ 25
Water Quality	-20	+ 20
Exchange Capacity	+ 1	+ 20
Total Range of Values	-13	+150

Table Human use parameters.

A. Aesthetic Values

Generate a *subjective* judgment of the overall aesthetic value of the wetlands system in question. Consider size, biological diversity, setting and human use potential in this rating. Defend the subjective judgment with expository material prepared with reference to the measurable parameters. Range: 1-30.

B. Present Value of Wetland Products and Services

Calculate the present value of the wetland in question on both a short (0-50 years) and long term basis (50-500 years). Consider the real dollar value of each of the products (e.g., waterfowl, fish production, natural plant foods) of the wetland plus the value of whatever services (e.g., sediment trap, water quality improvement, etc.) to environmental quality are provided. Rate the value on a 1-30 basis with +30 equal to a value in 1978 dollars of $3,000. per acre, and+1 equal to $100. or less per acre.

C. Rate the Potential Economic Value of Various Potentially Competitive Uses of the Wetland in Question

Include the following uses at minimum over a short term,<50 years,and long term basis, 50-500 years: a.) Existing wetlands function and use; b.) Most likely wetlands function and use given existing development (or non-development) trends in its watershed; c.) If converted to agricultural uses; d.) If used for proposed development purposes. Make a short term and a long term projection of the economic returns to society for the wetland in question under the four options above. Numerical value: 1-30 with 1 an overall value equal to the wetland's intrinsic value if left alone. To earn a +30 rating, the proposed use *must return to society** five times the intrinsic value of the wetland over the long term perspective (500 years). Schedule ratings in proportion to the five times x 500-year standard; these ratings can be determined on a 50 x 50-year projection as well.

D. Recreation Values

Measure recreational values of the wetland under study by examining existing and potential hunting, fishing and boating uses including indirect effects such as value as a rearing area for sport fish and game species. Consider all possible uses of the existing wetland, and those most likely to be developed, used and preserved. Rate values from 1 to +30. Measure this service in terms of +1 for no measurable recreational value to +30 for 60 person-days of recreational use per hectare of wetland per year.

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*NOTE: The intent is to insure that what is measured is the long term economic value which accrues to society in exchange for the loss of cost-free services (3) and not simply the short term return on investment to the proposer.

Table Human use parameters (concluded).

E. Rareness of the Wetland Resource

Determine the rareness of the specific wetland type and biological resources under study on a local and statewide basis. If the wetland is unique, rate it +30, if abundant, +5. Rareness should be referenced to hydrology, species present, and the specific biological communities present. Unique = +30; Very Rare = +25; Rare = +20; Uncommon = +15; Common = +10; and Abundant = +5.

F. Management Potential

Determine whether it is possible to maintain the wetland in its present form given available, realistic management options and existing development trends. For example, if a high value wetland of small size will certainly be encircled and its watershed afflicted with high density urbanized land uses in the short term, *many desirable management options and wildlife species will be irrevocably lost regardless of what occurs in the wetland in question.* Rating from 0 to -20, with 0 if the wetland can be maintained substantially as is for >50 years, and -20 if other development actions in the short (< 50 years) will do severe damage to the wetland regardless of specific actions taken in the wetland. ("Severe damage" is defined here as a 50% loss of baseline wetland values.). Include in this rating a consideration of cost to maintain the system as is given the development trends in the wetland's watershed.

G. Holistic Ecosystem Importance Rating

Develop an holistic ecosystem importance rating that is the weighted sum of plant diversity, animal diversity, critical habitat rating, watershed importance rating, aesthetic value rating, and economic value rating divided by n-1=5. Ecosystems are known to consist of the species present, their environment plus their symbioses and interactions. Only in a high quality wetland will all six of these factors be high and, hence, symbioses high. Rating Value: 1-27.

IV. OVERALL SYSTEM RESILIENCE TO DISTURBANCE

Overall ecosystem resilience to natural and human disturbance is basically a measure of the fragility of the wetland system in question. Some systems (e.g., the acid bog lake or the alkaline fen) are exceedingly fragile systems that can be destroyed by a significant change in just one factor (pH). Other systems, such as mature marshlands with significant peat accumulations, can absorb many environmental insults and still retain much of their essential character through time. Rate as +50 a system that can tolerate or resist deleterious fire, watershed alteration, and various pollutants and +1 a system that virtually any natural disaster of human pollution will surely destroy. This is basically a measurement of a wetland's ability to persist. This is partly a subjective rating that must be done by a qualified ecologist on an holistic basis based on the observations made in categories I-III above, a review of relevant ecological literature (e.g., van der Valk and Davis, 1978) and experience with wetlands.

Table Summary of human use parameters weighting system.

Human Use Parameter	Minimum Value	Maximum Value
Aesthetic Values	+ 1	+ 30
Economic Values	+ 1	+ 30
Value of Competitive Uses	+ 1	+ 30
Recreational Values	+ 1	+ 30
Resource Rareness	+ 5	+ 30
Management Potential	-20	0
Holistic Ecosystem Values	+ 1	+ 27
Total Range of Values	-10	+177

Table Summary of parameter weighting for major categories.

		Range of Values		
I.	Biological Parameters	+ 9	to	+205
II.	Hydrological Parameters	-13	to	+150
III.	Human Use Parameters	-10	to	+177
IV.	Wetland Resilience Rating	0	to	+ 30
	Total Range of Values Possible	-14	to	+532

APPENDIX I

Pollution Coefficients from Zimmerman (1974)

Industrial Pollution Coefficients

An approach for estimating direct industrial pollution for air, water, and solid wastes is outlined in the summary matrix below.

Direct industrial wastewater coefficients for estimating potential pollution from process water are given for a selected set of 40 industries in Tables C-4 through C-7 in Appendix C from Zimmerman (1973). These industries are generally considered the largest generators of wastewater and water pollutants of all industries. Table C-4 gives coefficients for wastewater volumes by industry. Table C-5 compares wastewater volumes from literature sources to actual reported wastewater discharge figures in permits required under the Federal Water Pollution Control Act Amendments of 1972 (the National Pollutant Discharge Elimination System). A fairly good correspondence is noted. Table C-6 gives water pollutants in terms of concentrations and Table C-7 gives them in terms of pounds per pound of industrial output. The code for data quality in these tables is:

Data Reliability Index

1 = Data represent the convergence of many independent inventories, each consisting of a large sample taken over relatively long periods of time and at frequent intervals.

2 = One or two inventories with a large number of samples.

3 = Plant operating experience for several plants consisting of 24-hour composite samples taken at frequent intervals.

4 = Plant operating experience for only a few plants, consisting of 24-hour composite samples over a limited range of time, or an estimate based on national averages.

5 = Data based upon grab samples only.

Direct Industrial Waste Generation
Summary Matrix

Water		Air	Solid Wastes	
Non-process	Process		Non-process*	Process
Potential Waste Generation				
30 gal./capita per day	(See accompanying tables for wastewater coefficients for about forty industries at the four digit SIC level in Appendix C.)	See: USEPA. Compilaation of Air Pollutant Emission Factors. Research Triangle Park, N.C.: USEPA, April, 1973.	Unknown	Unknown
Actual Waste Generation				
30 gal./capita per day	Consult USEPA effluent guidelines or reduce potential pollution by alternative percentages, ranging from 80-99%.	New Source Performance Standards; Stationary source standards; plus Potential emissions for materials not covered by standards.	Unknown	For specific data see Steiker (1974)

*Non-process solid wastes from industry include packaging material from supplies, waste office paper and cardboard, cafeteria wastes (bottles, paper, organic waste, cans), construction and demolition wastes, waste from sanitary facilities, flyash and cinder from onsite power facilities, if used.

Potential water pollutants can be reduced to actual pollutants by: 1) substituting effluent guidelines where they exist and 2) reducing them by the percentage of known removal efficiencies of various wastewater treatment systems.

Indirect water coefficients can be calculated in a manner similar to that suggested for residential and commercial development in the next section.

Residential/Commercial Pollution Coefficients

Direct water pollution from residential and commercial facilities is generally averaged for combined residential and commercial development at approximately 150 gallons per capita per day of wastewater and at about .08 to .14 pounds per capita per day for biological oxygen demand.

Direct air pollution is estimated almost exclusively as fuel usage and coefficients for various kinds of fuel are given in the Compilation of Air Pollutant Emission Factors.

Direct air pollution from residential and commercial activity in addition to resulting from fuel usage consists of air pollutants generated during solid waste disposal. Particulate emissions for alternative methods of disposal are:

Open burning	50-100 lb/ton
Poor apartment house incineration	about 50 lb/ton
Good apartment house incineration	10-20 lb/ton
Average municipal incineration	20-30 lb/ton
Good municipal incineration	10-20 lb/ton

(Regional Plan Association, 1968, p. 93.)

Preliminary solid waste coefficients, based upon the New York Metropolitan area figures are .51 to .68 tons per capita per year for residential solid wastes and .75 to 1.75 tons per employee per year for business solid wastes, which includes light industry and commercial wastes (Regional Plan Association, 1968, p. 91).

The increase in indirect potential water pollution generation takes the form of increased runoff from impervious surface created by new development. Runoff is a function of the intensity of rainfall, the slope of the land, land cover, and the size of the drainage area. The general formula for computing runoff is:

$$R = CIA$$

where C is the coefficient of runoff, I the intensity of rainfall, and A the size of the drainage area in acres. Some of the values of the terms for specific types of development are given in Table 1 below.

The runoff equation only estimates the volume of water that will run over the land instead of being absorbed by it given a certain level of development. The impact of the development really has to be expressed as the difference between the amount of runoff that would occur were the development not to take place and if it does take place. Furthermore, the runoff equation does not give the amount of water pollutants carried by the water runoff. A number of studies have been done to measure the pollutant content of runoff, and coefficients can be developed from those studies done in areas analogous to the area to be studied.

These potential pollutant figures could be transformed into actual figures using the degree of treatment generally accomplished for storm water runoff.

A (Drainage Area)

Drainage areas can be identified and measured from a USGS topographic map, or from engineering studies if these are available.

The amount of acreage and impervious surface generated by residential development that results from population growth has to be determined before the runoff equation can be applied to estimate indirect water pollution. Acreage can be estimated from zoning maps or from coefficients of space use per housing unit by housing type.

Table 1

Estimated Values for Terms in the Runoff Equation[a]

C (Coefficient of Runoff)

Residential Development[b]	C
10 families per acre	0.3-0.5
40 families per acre	0.5-0.7
More than 40 families per acre	0.7-0.9
Commercial Development[c]	0.9
Open areas[d]	
"Macadam, compacted earth and gravel, without plant growth	0.7
Impervious soil, with plant cover	0.5
Lawns and planted areas, with normal soil	0.2
Woods"	0.1

I (Intensity of rainfall)

$$I = K/t+b$$

where I = rainfall in inches per hour, t = average duration of storms in minutes, and K and b are coefficients assuming the following values:

Residential development in New Jersey (based on 5 and 10 year storms which Lynch recommends for these areas):

$K = 131\text{-}170$
$b = 17\text{-}19$

Commercial development (based on 25 and 50 year storms which Lynch recommends for these areas):

$K = 230\text{-}250$
$b = 24\text{-}27$

---

[a] Source: K. Lynch, 1962, p. 173-175.
[b] Included impervious areas, lawns, etc.
[c] Assumes that commercial development is entirely impervious and has a zero slope. Includes parking lots, access roads, and roofs.
[d] Assumes a zero slope. For slopes, coefficient should be increased.

Extent of impervious surface for the area has to be estimated by population density and housing type.

In order to apply the runoff equation to commercial development, the extent of commercial development in acreage that will accompany population growth has to be estimated. This can be estimated in the following ways:

(1) From zoning maps: commercially zoned land can be measured.

(2) From modifications of coefficients such as the following for shopping centers:

Population Served	Selling Area
Neighborhood Center (10,000)	40,000 sq. ft.
Community Center (20,000-100,000)	100,000-300,000 sq. ft.
Regional Center	50, 75 or 125 acres (depend of amount of expansion planned)

Source: Lynch, 1962, p. 327-328.

Once acreage is determined, the amount of impervious surface has to be estimated in order to obtain a value of C for the runoff equation. It must be remembered that the degree of impervious surface for commercial developments depends upon the layout of the development.

Another indirect form of pollution from residential, commercial or any other kind of development is the loss of soil or erosion caused by the action of water on land exposed during construction, or whose capacity to resist water movement has been reduced because of changes in slope or cover of the land. The amount of soil lost per acre of exposed land during a given storm period can be estimated from an equation, called the Universal Soil Loss Equation, originally developed by the Agricultural Research Service for erosion from agricultural activity. The general form of the equation is as follows:

$$\text{Soil loss} = R \times K \times SL \times C$$

where,

R = rainfall intensity or the average annual rainfall index for the area
K = a scale factor for soil erodability
SL = slope length and the angle of the slope
C = soil cover

Details on the precise application of the equation can be obtained from the US Department of Agriculture's Soil Conservation Service.

APPENDIX J

New Jersey (1975) indirect impact Analysis Methodology.

GUIDELINES FOR EVALUATING SECONDARY IMPACTS OF REGIONAL SEWERAGE SYSTEMS

The environmental assessment which accompanies each facilities plan must include a discussion of the secondary impacts of the proposed facility. According to federal regulations, secondary impacts include changes in the intensity and distribution of the population, and changes in the human use of the land. Because secondary impacts are a measure of long-range and lasting effects of a project, analysis of secondary impact should be at least as lengthly and detailed as that for primary impacts. The following guidelines are offered to assist in addressing this question.

1. Growth Experience of the Service Area

A. . Describe the growth experience of each municipality and the whole study area since 1960, including changes in size of population, types of residential development, types of industrial and commercial development, and changes in other major uses of land, such as farming. Map this information.

B. How does this growth experience in the service area compare with the rest of the county and with the state as a whole in terms of population, employment, building permits granted, industrial development?

C. Rank in order of importance the major factors influencing growth in the area and give rationale behind choices; for example:

proximity to metropolitan areas
accessibility – highways, public transport
natural resources – water supply, aquifers, prime farmlands
natural features – mountains, streams, ocean
inexpensive land
buildable land
public facilities
etc.

D. Determine the degree of development activity in each municipality in the sewer service area by showing how much development by type – commercial, single family residential, apartments, PUDs, industrial, etc., has been approved in the past two years. Look also outside the specific service area for indications of development pressure in the region including planned capital facilities.

1. Based on recently proposed subdivisions and building permit applications, estimate the amount of residential development that is likely to be constructed in the next few years. Determine the number of potential dwelling units which will probably be built without the proposed project.

2. Indicate lands which are known to be held by speculators and developers. In New Jersey a copy of every deed recorded with the County Clerk's Office is sent back to the municipality. So information relating to changes in ownership should be available at municipal offices. The county agricultural agent will be a useful source of information in this regard.

II. Existing Land Use

A. On map or photo quad of the service area at U.S.G.S. scale, map publicly owned lands, floodplains, wetlands, etc.

B. Map undeveloped lands and determine the number of vacant acres. Subtract publicly owned lands, floodplains, wetlands, slopes exceeding 15%, etc. to determine the number of vacant, developable acres in each municipality and in service area.

C. List any major deterrents to growth, both natural and other, e.g., lack of water supply, lack of sewers, bad drainage, difficult terrain, stream loading limitations, etc.

(This information will have already been obtained for the inventory of natural resources required in the preparation of a facilities plan.)

D. At same scale as above, preferably as an overlay, map current zoned densities, taking these from each municipality's zoning map and ordinance. Deduce from this current zoned capacity of the service area.

III. Relationship to Future Plans

A. Study future land use plans where they exist of each municipality in the service area. Indicate the status of these plans. Are they official, adopted plans? When were they prepared and adopted? If no plans exist, review the zoning ordinance. If neither exists, so note.

B. Describe all other applicable planning for the service area, including regional and county future land use plans, state highway plans, state open space plans, plans for environmentally critical areas, i.e., floodplains, wetlands, coastal zones, etc. Confer particularly with county planners for this overview. Are local plans consistent with these county, regional and State plans? Point out major discrepancies. Separate planned expenditures from general plans.

C. How does the provision of the proposed facility relate to the above plans? Does it propose sewers in areas designated for conservation, open space, recreation or in environmentally critical areas? Where conflicts exist, how is the system designed to deal with them?

IV. Status of Planning in Each Municipality

A. What is the attitude toward growth in each of the participating municipalities? Determine this by examining municipal records, interviewing public officials, planning consultants, citizens, and reviewing area newspapers.

B. How much has each municipality in the service area spent on planning in each of the last five years? Show the relationship between the amount of vacant, developable land they have and the amount of money they spend for planning.

C. Describe the degree to which each municipality has dealt with the following checklist of basic planning elements:

1. Inventory of natural resources, including geology, soils, topography, water quality, water supply.
2. Open Space Needs Study and Open Space Plan.
3. Housing Needs Study and Housing Plan.
4. Collector Sewer Master Plan.
5. Adopted Master Plan which encompasses the above elements.
6. Provisions in zoning ordinance providing for "timing of development," clustering, PUD and PURD.
7. A six-year capital program.
8. Describe municipalities' current debt status and capacity.

D. Evaluate the consistency of the municipalities' land use ordinances and their plan. (Note inconsistencies in terms of impact on system design.)

E. Examine the records of the Zoning Boards of Adjustment for the past five (5) years in the service area.

1. What is the frequency of use or "d" variances?
2. To what extent are they a departure from the plans and adopted land use regulations; note especially:
    a. changes in density
    b. marked changes in type of use
    c. marked changes in waste discharge characteristics of permitted uses
3. Discuss the potential impact on system design where significant Zoning Board activity has been occurring.

V. Estimating Growth

The Environmental Assessment must take into account the assumption that putting through sewer interceptors will stimulate pressures for development. The growth which will follow the construction of the project must be estimated in order to deduce the potential impacts on natural resources, public services, fiscal policy and the character of the area.

A. For each alternative indicate on a map of the service area (no smaller than U.S.G.S. scale) the location and size of proposed sewer lines and treatment plants. Aerial photographs available at U.S.C.S. scale, 24,000:1, is a useful base on which to lay out proposed systems.

In light of municipal policies, proposed developments, and amount of development pressure discussed above and with careful analysis of the vacant, developable land which will be served by the proposed system, estimate the population which will occur in the service area within the 10 years following the construction of the proposed project. This could be a range rather than a single figure. It will be necessary to estimate the spatial pattern, density and general housing types which will probably occur. Where assumptions are made, they should be clearly stated and justified.

B. For purposes of comparison, also estimate an ultimate population for the service area based on the design size of the pipes, assuming full capacity use. Evaluate the engineer's assumptions about per capita use and peak flows as well as his methods for computing pipe sizes.

C. Under current state and local policies toward zoning, floodplains, critical areas, septic tanks and package treatment, what growth would occur if the project were not constructed using the 10 year time frame.

VI. Measuring Potential Impact of the Proposed Facility (and Alternatives).

Using growth estimates from Section V. A., determine the potential impacts of development on: regional economic patterns, transportation, local sewer collector systems, health services, solid waste disposal, schools, municipal fiscal structure, air quality, water supply, flooding, water quality downstream effects and the character of the region.

A. The impact of each of these should be analyzed for each municipality in the service area using referenced standards.

1. *Regional economic patterns.* What will be the impact (positive and negative) of growth on the following economic activities: agriculture, industrial development, retail business and services? This analysis should include geographic as well as measured aspects.
2. *Transportation.* How many additional cars for residents, commuting-in traffic and service vehicles will be generated? What new roads and road widenings will be necessary to serve this additional traffic? Estimated pattern of development under Section V.A. of these Guidelines will be useful here. Approximate costs. How will the burden be divided up between federal, state, county and local government?

Will a public transportation system be possible within the region if it doesn't exist now?

3. *Local sewer collector systems.* How much sewerage will have to be constructed by each municipality? Estimate costs. Add costs of local system to costs of regional system to produce estimated total cost to users 10 years after construction of regional project. Is the cost high enough to create pressure for more users?

4. *Health Services.* Estimate demand for hospital beds, nursing home beds, and other services as identified by the State Comprehensive Health Planning Agency.

5. *Solid waste disposal.* Estimate the amount of solid waste (tons per month) which will have to be collected and disposed of. Are there plans for dealing with this? Have sites been chosen? What will be approximate yearly costs for facilities and operations? Are there available approved disposal areas in the area?

6. *Schools.* How many additional school children can be anticipated? Using the estimated number of additional housing units in V.A. and accepted standards for the number of school children per unit.[1] Based on current cost per school child per year in each municipality, estimate future annual operating and construction costs. Relate the latter to debt section below.

7. *Municipal fiscal structure.* What are the anticipated effects of increased population on the fiscal position and tax rates of each municipality. Indicate whether or not there might be an increased financial burden on residents and if so, to what degree. (Again, it may be necessary to discuss this in terms of a range of possibilities.)[2] What are the capabilities of the towns with respect to their current and future debt capacity characteristics?

8. *Clean air.* What is existing air quality in the region based on current readings for particulates, photo chemical oxidants and sulphur oxides? With anticipated growth what would be the projected amount of deterioration in air quality in regard to these three parameters? Is this within the bounds of the EPA air quality increment standards?

9. *Water supply.* What are the current sources of potable water and what is the adequacy of such sources for meeting estimated future population needs? Determine what other sources might be available, how they might be brought into use and the approximate cost involved. Is depletion of streams or wastewater loading a concern in planning for future water supply?

10. *Flooding.* To what extent will the amount and speed of run-off be increased by estimated changes in land use, and what effect will this increased run-off have on frequency and magnitude of floods for 25-year storm, for 50-year storm?[3]

11. *Water quality.* What are the anticipated effects on stream quality and underground water quality of the run-off and increased wasteload resulting from the estimated development?

12. *Character of the region.* Would there be any significant changes in the appearance or functioning of the region which should be documented?

B. What are the most significant problems which can be foreseen as the result of the above described impacts of growth? Describe them at length.

---

[1] *See Explanatory Notes at end of guidelines.*

[2] *See Explanatory Notes at end of guidelines.*

[3] *See Explanatory Notes at end of guidelines.*

C. Is the design and construction schedule of the proposed facility compatible with phasing of growth in the individual municipalities and in the region, or will large areas be opened up all at once?

VII. Weighing Alternatives

A. Which of the alternative proposals best minimizes adverse secondary impacts while providing an adequate solution to the water quality problems of the area?

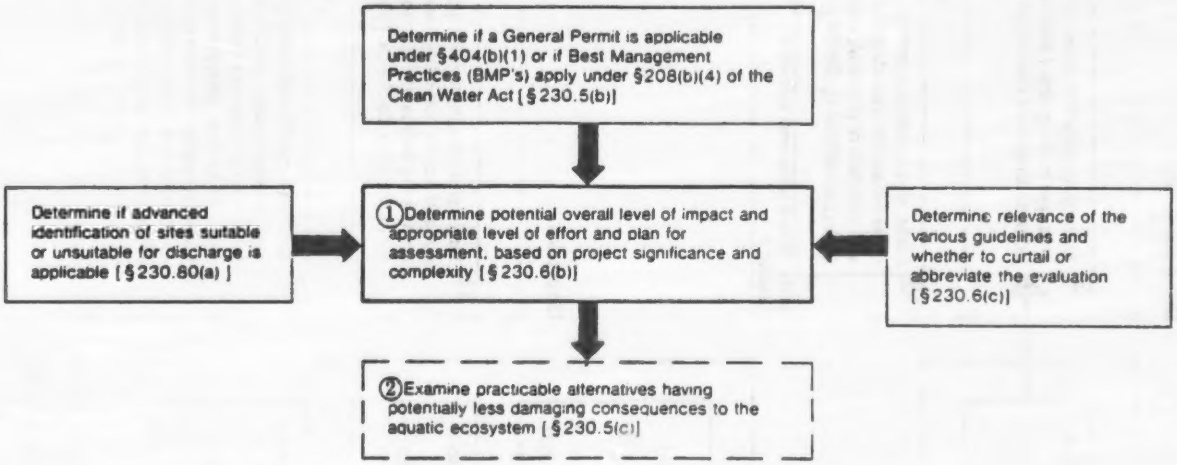
B. It is possible that each of the proposed alternatives represents too large a solution in relation to existing problems, thus threatening the area with unnecessary secondary impacts. If this is the case, indicate ways in which you feel the project might be revised, scaled down or staged and still solve the water quality problems of the area.

VII. Qualifications of Consultants

A. It is apparent that preparation of an analysis of secondary impacts should be a team effort. Identify persons who prepared the statement and their qualifications in the fields of planning, traffic engineering, economics, hydrology, sanitary engineering, etc.

APPENDIX K

Procedure recommended by USCOE
to evaluate dredge and fill sites
(from Nelson *et al*. 1982)


Determine if a General Permit is applicable under §404(b)(1) or if Best Management Practices (BMP's) apply under §208(b)(4) of the Clean Water Act [§230.5(b)]
Determine if advanced identification of sites suitable or unsuitable for discharge is applicable [§230.80(a)]
①Determine potential overall level of impact and appropriate level of effort and plan for assessment, based on project significance and complexity [§230.6(b)]
Determine relevance of the various guidelines and whether to curtail or abbreviate the evaluation [§230.6(c)]
②Examine practicable alternatives having potentially less damaging consequences to the aquatic ecosystem [§230.5(c)]

PREASSESSMENT PHASE: STEP 1

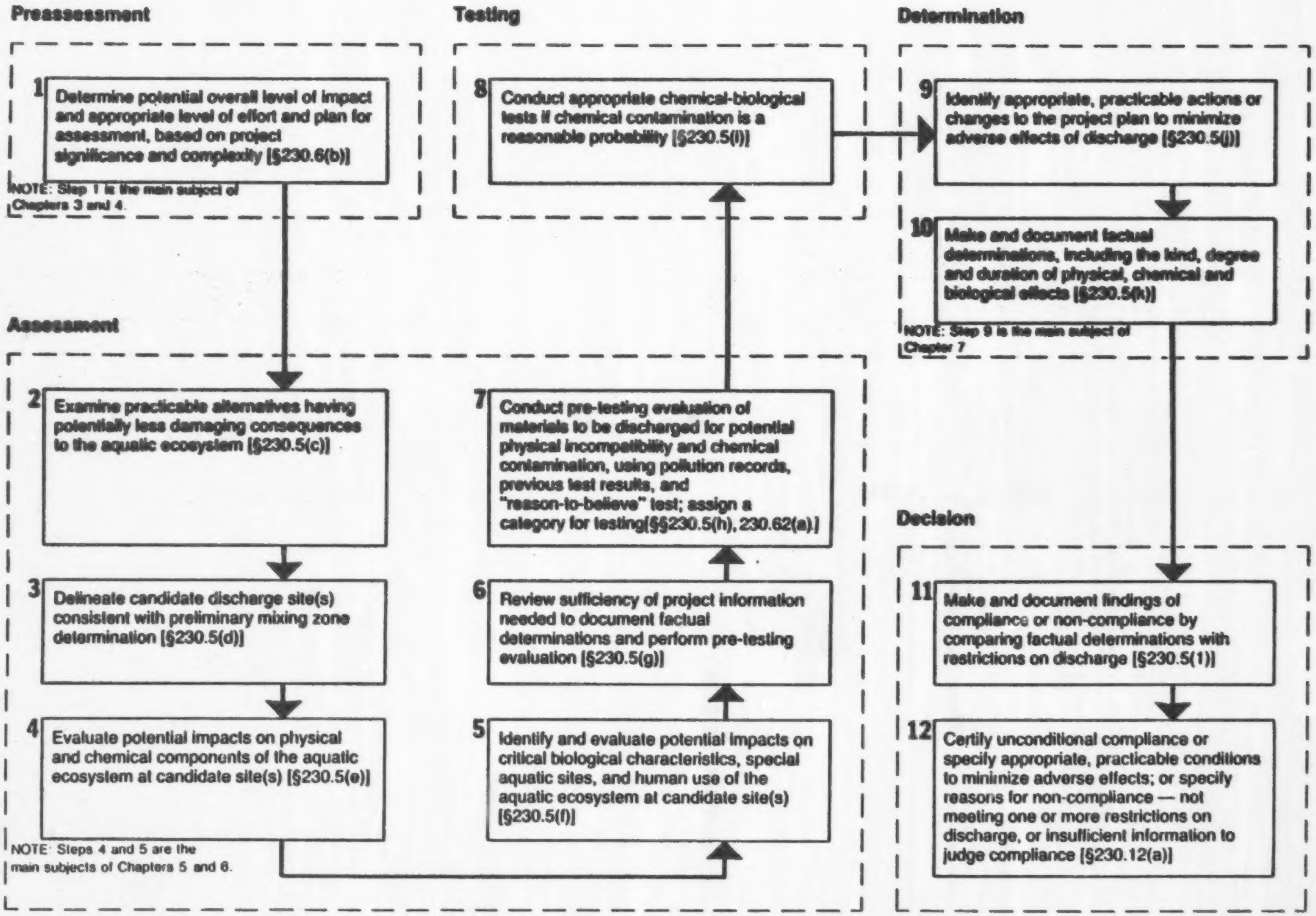
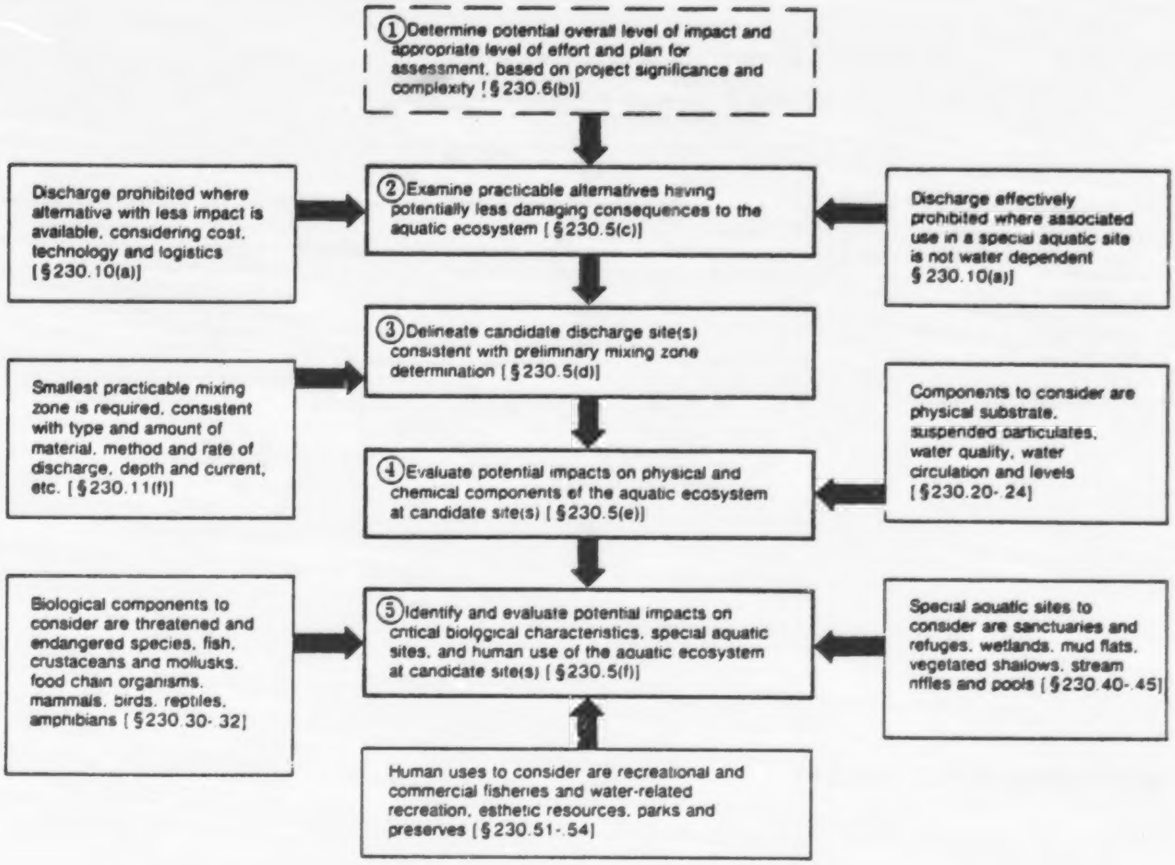

Preassessment
1 Determine potential overall level of impact and appropriate level of effort and plan for assessment, based on project significance and complexity [§230.6(b)]
NOTE: Step 1 is the main subject of Chapters 3 and 4.
Testing
8 Conduct appropriate chemical-biological tests if chemical contamination is a reasonable probability [§230.5(i)]
Determination
9 Identify appropriate, practicable actions or changes to the project plan to minimize adverse effects of discharge [§230.5(j)]
10 Make and document factual determinations, including the kind, degree and duration of physical, chemical and biological effects [§230.5(k)]
NOTE: Step 9 is the main subject of Chapter 7
Assessment
2 Examine practicable alternatives having potentially less damaging consequences to the aquatic ecosystem [§230.5(c)]
3 Delineate candidate discharge site(s) consistent with preliminary mixing zone determination [§230.5(d)]
4 Evaluate potential impacts on physical and chemical components of the aquatic ecosystem at candidate site(s) [§230.5(e)]
NOTE: Steps 4 and 5 are the main subjects of Chapters 5 and 6.
7 Conduct pre-testing evaluation of materials to be discharged for potential physical incompatibility and chemical contamination, using pollution records, previous test results, and "reason-to-believe" test; assign a category for testing[§§230.5(h), 230.62(a)]
6 Review sufficiency of project information needed to document factual determinations and perform pre-testing evaluation [§230.5(g)]
5 Identify and evaluate potential impacts on critical biological characteristics, special aquatic sites, and human use of the aquatic ecosystem at candidate site(s) [§230.5(f)]
Decision
11 Make and document findings of compliance or non-compliance by comparing factual determinations with restrictions on discharge [§230.5(1)]
12 Certify unconditional compliance or specify appropriate, practicable conditions to minimize adverse effects; or specify reasons for non-compliance — not meeting one or more restrictions on discharge, or insufficient information to judge compliance [§230.12(a)]

Figure 2.1-1. Five phases and 12 basic steps in evaluating a proposed site for discharge of dredged or fill material consistent with USEPA §404 (b)(1) guidelines (Nelson & Associates, Inc. 1981).



① Determine potential overall level of impact and appropriate level of effort and plan for assessment, based on project significance and complexity [§230.6(b)]

Discharge prohibited where alternative with less impact is available, considering cost, technology and logistics [§230.10(a)]

② Examine practicable alternatives having potentially less damaging consequences to the aquatic ecosystem [§230.5(c)]

Discharge effectively prohibited where associated use in a special aquatic site is not water dependent §230.10(a)]

Smallest practicable mixing zone is required, consistent with type and amount of material, method and rate of discharge, depth and current, etc. [§230.11(f)]

③ Delineate candidate discharge site(s) consistent with preliminary mixing zone determination [§230.5(d)]

④ Evaluate potential impacts on physical and chemical components of the aquatic ecosystem at candidate site(s) [§230.5(e)]

Components to consider are physical substrate, suspended particulates, water quality, water circulation and levels [§230.20-24]

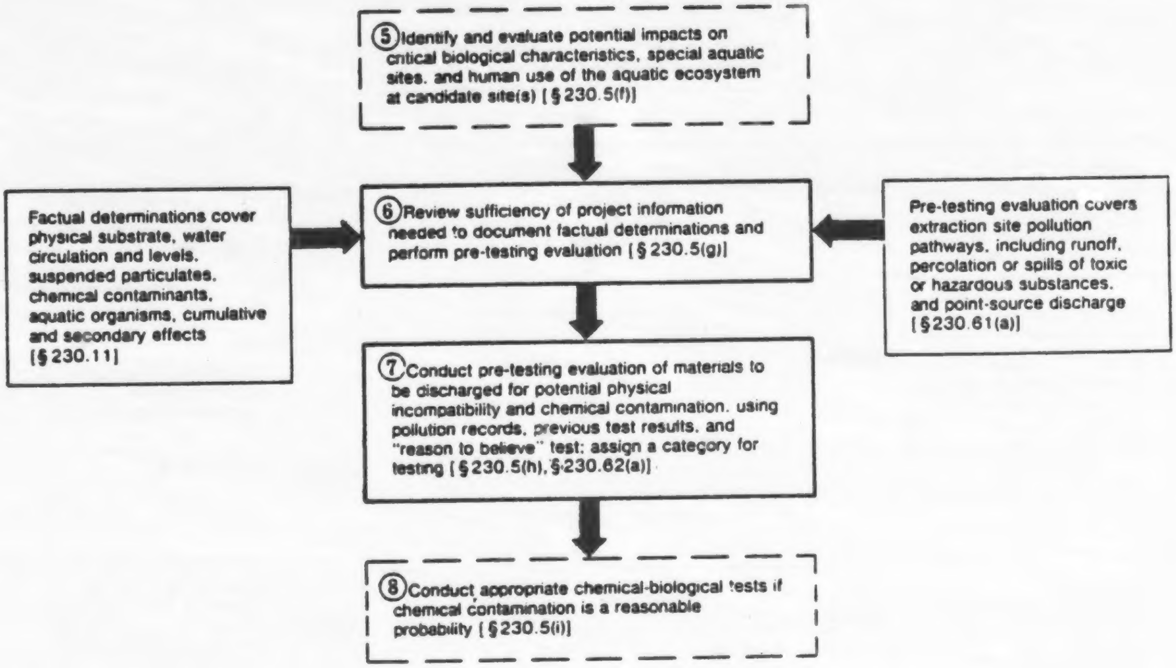
Biological components to consider are threatened and endangered species, fish, crustaceans and mollusks, food chain organisms, mammals, birds, reptiles, amphibians [§230.30-32]

⑤ Identify and evaluate potential impacts on critical biological characteristics, special aquatic sites, and human use of the aquatic ecosystem at candidate site(s) [§230.5(f)]

Special aquatic sites to consider are sanctuaries and refuges, wetlands, mud flats, vegetated shallows, stream riffles and pools [§230.40-45]

Human uses to consider are recreational and commercial fisheries and water-related recreation, esthetic resources, parks and preserves [§230.51-54]

ASSESSMENT PHASE: STEPS 2-5



⑤ Identify and evaluate potential impacts on critical biological characteristics, special aquatic sites, and human use of the aquatic ecosystem at candidate site(s) [§ 230.5(f)]

Factual determinations cover physical substrate, water circulation and levels, suspended particulates, chemical contaminants, aquatic organisms, cumulative and secondary effects [§ 230.11]

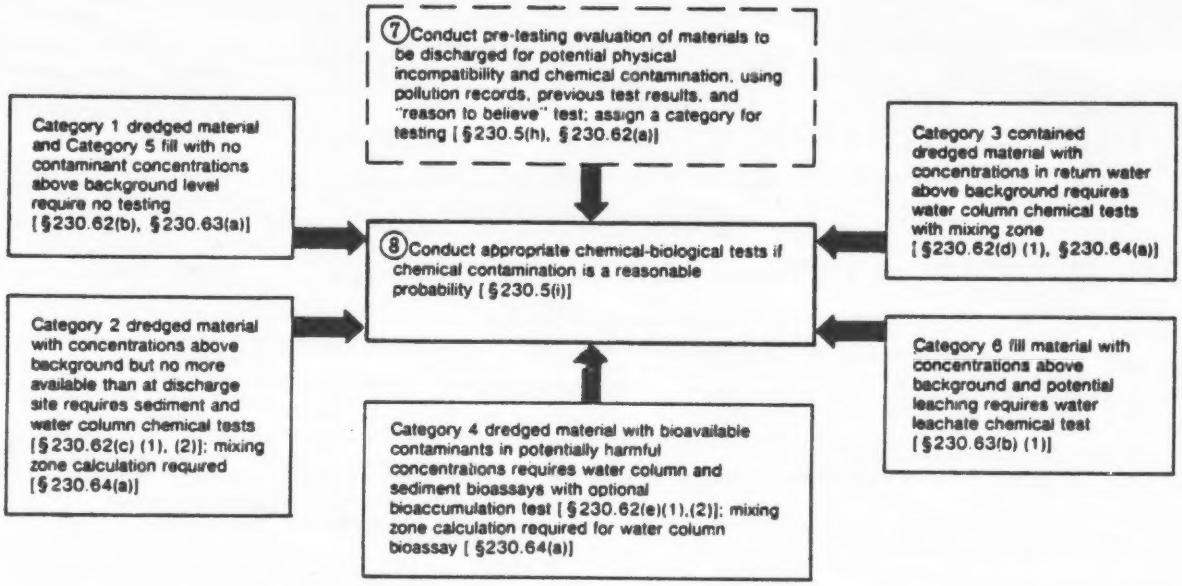
⑥ Review sufficiency of project information needed to document factual determinations and perform pre-testing evaluation [§ 230.5(g)]

Pre-testing evaluation covers extraction site pollution pathways, including runoff, percolation or spills of toxic or hazardous substances, and point-source discharge [§ 230.61(a)]

⑦ Conduct pre-testing evaluation of materials to be discharged for potential physical incompatibility and chemical contamination, using pollution records, previous test results, and "reason to believe" test; assign a category for testing [§ 230.5(h), § 230.62(a)]

⑧ Conduct appropriate chemical-biological tests if chemical contamination is a reasonable probability [§ 230.5(i)]

ASSESSMENT PHASE: STEPS 6-7



⑦Conduct pre-testing evaluation of materials to be discharged for potential physical incompatibility and chemical contamination, using pollution records, previous test results, and "reason to believe" test; assign a category for testing [§230.5(h), §230.62(a)]

Category 1 dredged material and Category 5 fill with no contaminant concentrations above background level require no testing [§230.62(b), §230.63(a)]

Category 3 contained dredged material with concentrations in return water above background requires water column chemical tests with mixing zone [§230.62(d) (1), §230.64(a)]

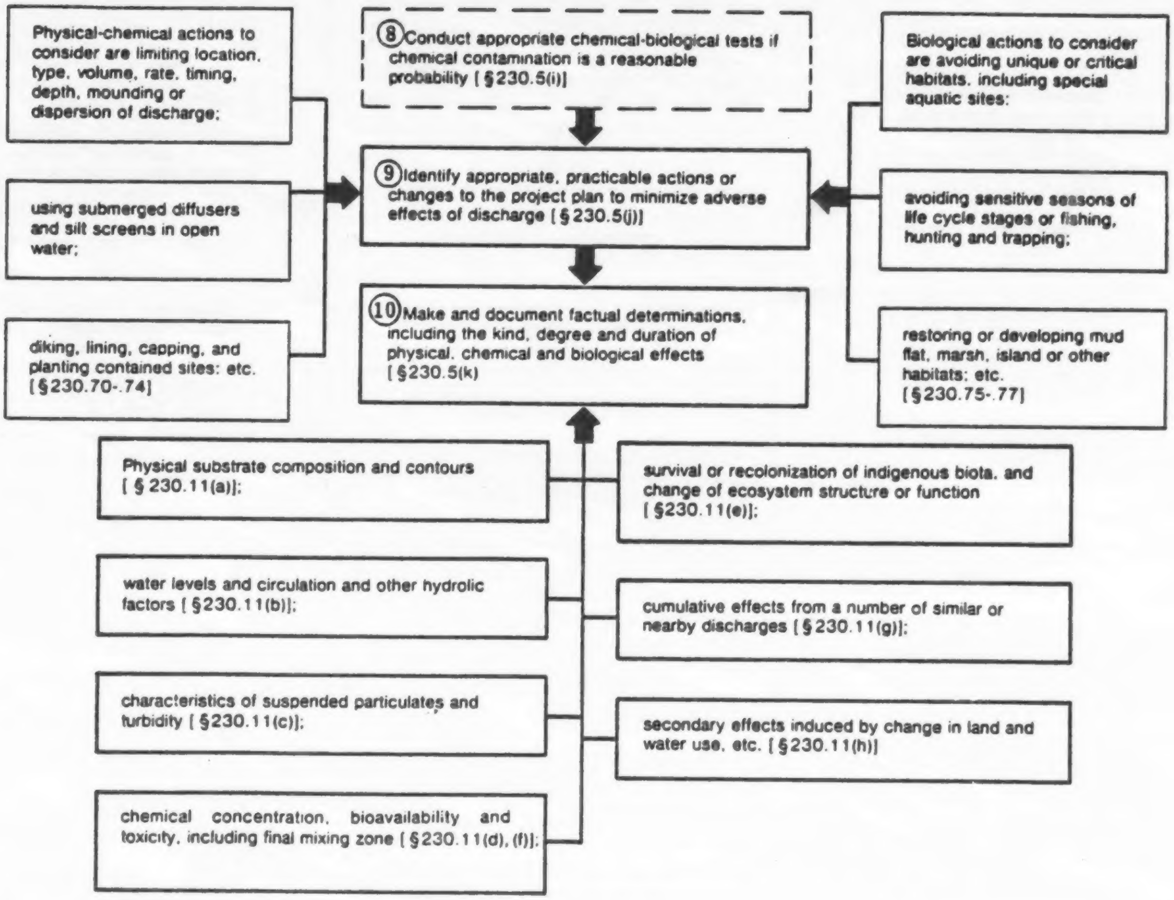
⑧Conduct appropriate chemical-biological tests if chemical contamination is a reasonable probability [§230.5(i)]

Category 2 dredged material with concentrations above background but no more available than at discharge site requires sediment and water column chemical tests [§230.62(c) (1), (2)]; mixing zone calculation required [§230.64(a)]

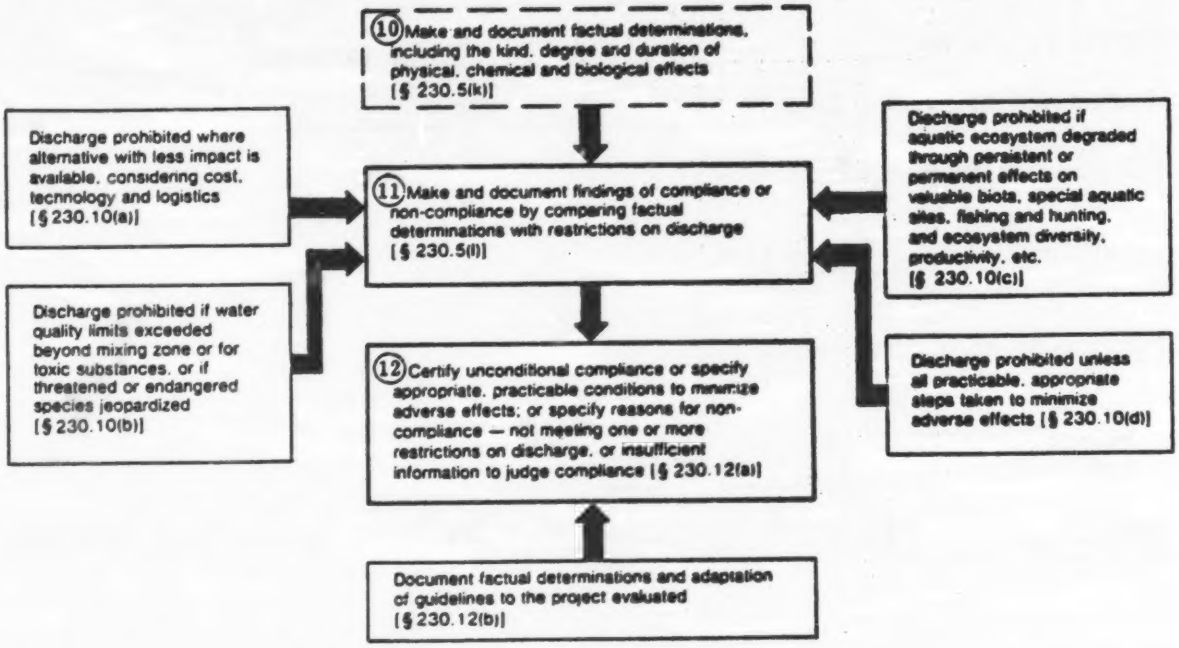
Category 6 fill material with concentrations above background and potential leaching requires water leachate chemical test [§230.63(b) (1)]

Category 4 dredged material with bioavailable contaminants in potentially harmful concentrations requires water column and sediment bioassays with optional bioaccumulation test [§230.62(e)(1),(2)]; mixing zone calculation required for water column bioassay [§230.64(a)]

TESTING PHASE: STEP 8


Physical-chemical actions to consider are limiting location, type, volume, rate, timing, depth, mounding or dispersion of discharge;
using submerged diffusers and silt screens in open water;
diking, lining, capping, and planting contained sites: etc. [§230.70-.74]
⑧ Conduct appropriate chemical-biological tests if chemical contamination is a reasonable probability [§230.5(i)]
⑨ Identify appropriate, practicable actions or changes to the project plan to minimize adverse effects of discharge [§230.5(j)]
⑩ Make and document factual determinations, including the kind, degree and duration of physical, chemical and biological effects [§230.5(k)
Biological actions to consider are avoiding unique or critical habitats, including special aquatic sites;
avoiding sensitive seasons of life cycle stages or fishing, hunting and trapping;
restoring or developing mud flat, marsh, island or other habitats; etc. [§230.75-.77]
Physical substrate composition and contours [§230.11(a)];
water levels and circulation and other hydrolic factors [§230.11(b)];
characteristics of suspended particulates and turbidity [§230.11(c)];
chemical concentration, bioavailability and toxicity, including final mixing zone [§230.11(d), (f)];
survival or recolonization of indigenous biota, and change of ecosystem structure or function [§230.11(e)];
cumulative effects from a number of similar or nearby discharges [§230.11(g)];
secondary effects induced by change in land and water use, etc. [§230.11(h)]

DETERMINATION PHASE: STEPS 9-10


⑩ Make and document factual determinations, including the kind, degree and duration of physical, chemical and biological effects [§ 230.5(k)]
Discharge prohibited where alternative with less impact is available, considering cost, technology and logistics [§ 230.10(a)]
⑪ Make and document findings of compliance or non-compliance by comparing factual determinations with restrictions on discharge [§ 230.5(l)]
Discharge prohibited if aquatic ecosystem degraded through persistent or permanent effects on valuable biota, special aquatic sites, fishing and hunting, and ecosystem diversity, productivity, etc. [§ 230.10(c)]
Discharge prohibited if water quality limits exceeded beyond mixing zone or for toxic substances, or if threatened or endangered species jeopardized [§ 230.10(b)]
⑫ Certify unconditional compliance or specify appropriate, practicable conditions to minimize adverse effects; or specify reasons for non-compliance — not meeting one or more restrictions on discharge, or insufficient information to judge compliance [§ 230.12(a)]
Discharge prohibited unless all practicable, appropriate steps taken to minimize adverse effects [§ 230.10(d)]
Document factual determinations and adaptation of guidelines to the project evaluated [§ 230.12(b)]

DECISION PHASE: STEPS 11-12

SECTION 10/404 PERMIT APPLICATION FIELD REPORT
U. S. Fish and Wildlife Service

Date of Inspection________________________

Reporting Biologist________________________

Public Notice No.__________________________, (dated)__________

Investigation Type: Section 10__________ 404__________

Applicant's Name and Address:

Waterbody and Location of Work:

Purpose of Work (describe):

Water-Dependent: Yes_____No_____
Public Benefit: Yes_____No_____

Description of Proposed Project (append maps depicting habitat types and copy of project plans):

Percent of work completed (if any)________________________________

Fill or Spoil Area:
Dimensions____
Total Acreage________________________
Acreage above m.h.w.________________
Acreage below m.h.w.________________
Method(s) to retain materials________________________________
____
Method(s) to prevent erosion________________________________
____
Intended use of filled area________________________________
____

Dredge or Borrow Area:
Dimensions____
Total Acreage________________________
Acreage above m.h.w.________________
Acreage below m.h.w.________________

Necessity for particular depth and/or width__________________________
____
____
Type of materials to be excavated______________________________
Quantity of materials to be excavated_____________________(cubic yards)
Quality of materials to be excavated________(polluted)________(non-polluted)
Type of pollutant____
____

Intended use of excavated area ______________________________

Method(s) of excavation ______________________________

Type(s) of equipment to be used ______________________________

List of private, state and federal fish, wildlife and recreation lands in area of project influence:

List of existing industrial, residential or other developments in area of project influence:

Extent of development on adjoining properties (i.e., bulkheading, filling, etc.):

Habitat Description Within Work Area:

		Acreage*		
	(%)	Dredged	Filled	Other
A. Vegetated Wetlands (Habitat type ______)**				
1. Predominant Emergent Plant Species				
______	___	___	___	___
______	___	___	___	___
______	___	___	___	___
______	___	___	___	___
______	___	___	___	___
2. Predominant Non-Emergent Plant Species				
______	___	___	___	___
______	___	___	___	___
______	___	___	___	___
B. Non-Vegetated Wetlands (Habitat type ______)				
______	___	___	___	___
______	___	___	___	___
______	___	___	___	___

C. Bottom type (i.e., sand, gravel, mud, shell, etc.), including depth and value as habitat:

*Sources of data (i.e., estimate, planimeter, etc.) ______________________________

**Use type in accordance with Circular 39, "Wetlands of the United States."

Environmental Alterations Which Would Result from Work:

		Significant	Insignificant	None
1.	Filled waterway or marshes	____	____	____
2.	Deepening	____	____	____
3.	Obstructing	____	____	____
4.	Shoaling	____	____	____
5.	Segmentation	____	____	____
6.	Habitat isolation	____	____	____
7.	Draining wetland	____	____	____
8.	Flooding wetland	____	____	____
9.	Bulkhead, dike, levees	____	____	____
10.	Diversion of freshwater sources	____	____	____
11.	Modification of tidal intrusion	____	____	____
12.	Modification of water circulation	____	____	____
13.	Increased fertility	____	____	____
14.	Reduced fertility	____	____	____
15.	Increased turbidity	____	____	____
16.	Noxious odor	____	____	____
17.	Tributary flow control	____	____	____
18.	Saltwater barrier	____	____	____
19.	Convert to fresh water	____	____	____
20.	Modification of substrata	____	____	____
21.	Pollution (specify type)	____	____	____
22.	Shoreline erosion	____	____	____
23.	Other	____	____	____

Fish and Wildlife Resources Within Project Area (list important species and identify primary habitat use as to (F)-feeding, (S)-spawning, (M)-migration, (N)-nursery, (R)-resting, or (W)-wintering):

Fish

Shellfish

Waterfowl

Shore and Wading Birds

Mammals

Rare and Endangered Species

Others

Utilization of Fish and Wildlife Resources in Work Area* (describe and quantify, if possible, use of important species):

Harvest

Sport fishing

Commercial fishing

Hunting

Trapping

Non-Consumptive Uses

Wildlife observation

Photography

Research

Education

Special Uses

Aquaculture

Shell collecting

Sanctuary

Other

Project Effect on Public Use in Area (i.e., access, esthetics, etc.):

Biological Significance of Area (describe briefly the importance or relationship of proposed work to fish and wildlife in area of influence, including any existing fish and wildlife management areas or plans for such developments):

---

*Sources of data ______________________________

Potential Direct or Indirect Effect of Environmental Alterations on Fish and Wildlife Resources and Their Use:

Conclusion(s):

Permit application should be:

1. Denied (summarize reasons).

2. Denied pending preparation and review of EIS (summarize reasons).

3. Modified (specify conditions and summarize reasons).

4. Issued as proposed (summarize reasons).

Field Reconnaissance Data:

Investigator(s) **Agency**

Date(s) of Investigation **Times of Investigation**

Method(s) of Investigation (boat, aerial, motor vehicle, on foot, etc.).

Field Conditions in Project Area

Sky cover: ( ) clear ( ) overcast ( ) cloudy

Wind: direction________ speed________(m.p.h.)

Temperature: air_______(°F)(°C)

water_______(°F)(°C)

Salinity________ppt

Other water analyses____

Tidal stage____

Water condition (clear, turbid, stained, etc.)_____________________

Sampling results (append data sheet, if any)

Photo information (attach photos)

APPENDIX L

Ontario Government
Biological Method

THE EVALUATION OF WETLAND VALUES

In this evaluation, wetland values are grouped into four separate components. These are biological, social, hydrological and special features. Each component is evaluated individually and separately from the others. The biological, social and hydrological components may each generate a total of 250 points. The special features component may generate extremely high scores (i.e. in excess of 1,000) but the likelihood of such high scores is extremely low.

With 250 possible points for each component one can develop a more sensitive point spread within "subcomponents" than if a lower maximum number had been chosen. The adoption of the high maximum total also permits "minor" values (ones to which only few points are allotted) to be more accurately included in the evaluation.

Within each component, subcomponent values have been weighted to reflect their relative importance (relative to each other). Some values are widely considered to be of major importance as for example, breeding habitat for an endangered species. At the other end of the scale are what might be termed as "minor" values, that is, ones which in any total point scale should properly be allocated only a few points. This evaluation takes the position that even "very minor" wetland values should be evaluated and included in the overall assessment because the evaluation seeks to be comprehensive. To avoid the measurement of known values (assuming, of course, that the information is practicable to collect) would appear to be contrary to the need to optimize accuracy.

In no case was the number (value) that was assigned to a variable arrived at lightly. The weighted values are the end product of a process involving numerous reviews and adjustments over a 2 year period made under the guidance of the Canada/Ontario Steering Committee on Wetland Evaluation. There was much field testing, consultation with outside "experts", and considerable deliberation. Thus, experience and calculated judgement about the relative importance of the accepted variables is the basis for the credibility of the numbers.

1.0. BIOLOGICAL COMPONENT

The biological component is evaluated under three major subcomponents, namely productivity, diversity and size. Productivity is evaluated by examining 5 interrelated values, namely growing degree days, wetland soils, kind of wetland types, site, and nutrient status of surface water. Diversity is evaluated by studying 6 characteristics:

number of wetland types, vegetation communities, diversity of surrounding habitat, proximity to other wetlands, interspersion and open water types. Size is evaluated by tying its value closely to wetland quality.

1.1. PRODUCTIVITY VALUES

Biological productivity provides a measure of the ability of a certain area to produce a crop of living organisms. Biological productivity may be either primary (if produced by chlorophyll-bearing organisms) or secondary or tertiary (if produced by non-chlorophyll bearing organisms). The form of "wetland energy" that is available to wildlife is that derived from primary productivity. Herbivorous wildlife (plant eaters; secondary productivity) consume this plant matter and are eventually themselves consumed by carnivorous wildlife (meat eaters; tertiary productivity). For this reason, primary production is a good indicator of the overall biological productivity; the more energy available, the more consumers the ecosystem can support. Because primary productivity provides a good general approximation of both secondary and tertiary productivity and because with certain exceptions (see 4.2) the evaluation of secondary and tertiary productivity would be a complex and time-consuming matter, only primary productivity is measured in the Biological Component.

1.1.1. Growing Degree-Days

Broadly speaking, the greater the amount of organic material or "biomass" that a community of plants can produce, the more becomes available for the use of man and of all forms of life that depend directly or indirectly on plants for food. The single most important factor contributing to the production of biomass is temperature (Lieth and Whittaker 1975; Edey 1977). Thus, in southern Ontario, most species of plants growing in their natural environment will produce more biomass at say 15° Celsius than they would at 10°C. As well, in areas of Ontario where average daily temperature is higher and the frost free season is longer, a greater diversity of plant species can also be found. This means that, in general, more species of animals can be sustained by those wetland plant communities that grow in areas with more favourable temperature regimes. An index which shows the contribution of warmer temperatures to plant growth has been created (Brown, McKay and Chapman 1968; Edey 1977) by recording the seasonal accumulation of "Growing Degree Days" (GDDs). The reason that this base temperature is chosen for the index is because in temperate climates plant growth essentially stops at lower temperatures.

The concept of growing degree days assumes that plant growth is related directly to the average daily temperature. It ignores soil temperature, differences in the pattern of night and day temperature and other variations caused by the stage of growth. The degree days for each day are added together, or accumulated, throughout the growing season (Edey 1977).

Thus we can say that the higher the number of GDDs the greater is the amount of biomass that plants in an area can produce by photosynthesis. Of course, other factors can severely influence the responses of various plant species in any particular wetland. For example, the availability of water, nutrients, light, water body morphology, rate of grazing or harvesting, nature of drainage, kinds of life forms present, and so on. But as a general rule the direct correlation between GDDs and plant biomass production is a positive one.

The number of GDDs across the landscape of southern Ontario is known (Brown, McKay and Chapman 1968). This means that GDDs can be correlated with geographical position of each wetland and it is for this reason that the GDD index is considered to be a generally applicable attribute to wetland evaluation in the province.

The geographical variation in GDDs in southern Ontario is mapped in Figure 1. The figure shows the lowest means are found in more northern and interior upland regions while the highest are found on Pelee Island.

Evaluation:

Growing Degree Days	
<2800	= 4
2800 to 3200	= 8
3200 to 3600	= 14
>3600	= 20

(Maximum possible = 20)

Wetland complexes should be evaluated by determining the GDD's at the approximate centre of the complex.

1.1.2. Soils

The contribution of soil type to productivity is well established both in agriculture and forestry. The inclusion of soils in the determination of wetland productivity is based on the assumption that in wetlands higher biological productivity would result when certain soil capability groups are present. Mineral soils are considered to be more valuable to productivity than organic soils even though it was the presence of a wetland environment that created the organic soils in the first place.

Evaluation:

Clays, loams or silts	% of area x 10
Organic	% of area x 6
Undesignated	% of area x 0

(Maximum possible = 10)

In wetland complexes the evaluator should aim at determining the fraction of area occupied by the 3 categories for the complex as a whole.

1.1.3. Type of Wetland

Wetlands may be comprised of different kinds of ecosystems such as marshes, swamps, bogs or fens. These are known as wetland types. The types are defined in the Procedures Manual (Part II). Type of wetland provides one of the best measures of primary productivity. It is well established that different ecosystems have different rates of productivity (Leith and Whittaker 1975) and wetlands are no exception (Greeson, Clark and Clark, 1979; Richardson 1979). Richardson (1979) studied the net primary productivity of a variety of wetland types and derived the following average figures: cattail marshes 24.7 metric tonnes per hectare per year (m.t./ha/yr.); sedge marshes 21.0 m.t./ha/yr; swamp forests 10.4 m.t./ha/yr., and bogs, fens and muskegs 9.3 m.t./ha/yr.

In this evaluation we recognize marshes, swamps, carrs, fens and bogs. Definitions of these wetland types are given in Part II as modified from Zoltai (1975) and others. Percent cover (of area) of each wetland type in the wetland is to be determined as this will provide a more accurate assessment of productivity.

Evaluation:

Bog	% of area x 4
Fen	% of area x 6
Carr	% of area x 10
Swamp	% of area x 12
Marsh	% of area x 20

(Maximum possible = 20)

In wetland complexes the percent of area occupied by each wetland type (in all individual wetlands of the complex) should be the basis for the evaluation of type of wetland.

1.1.4. Site

The physiographic position of a wetland in the landscape defines its site. Four site locations are defined in this Evaluation. These are Lacustrine; Riverine, Palustrine and Isolated. Wetland scientists differ somewhat in precisely how each of these four terms are defined (Cowardin et. al. 1979; Reid and Wood, 1976). The definitions used in this Evaluation are presented in Part II. As well, the four site locations are illustrated in Figures 2, 3, 4 and 5 in Part II.

The contribution of site to primary productivity is derived from the following considerations. The rate of flow of water is greater in Riverine wetlands and therefore more nutrients can flow through and be in contact with vegetation than in Isolated or Lacustrine wetlands. Thus more plant material can be produced in Riverine wetlands, particularly near rivermouths than in wetlands having a more limited nutrient source. The further downstream, the richer the nutrient concentration (Hynes, 1970). Many Lacustrine marshes, depending on location in the lake, are also very productive due to the local accumulation of nutrients.

Evaluation:

- Isolated	% of area x 2
- Palustrine with intermittent outflow	% of area x 4
- Palustrine with permanent outflow	% of area x 4
- Riverine (near headwaters)	% of area x 6
- Riverine (mid-river)	% of area x 8
- Riverine (near mouth)	% of area x 10
- Lacustrine (at river mouth)	% of area x 10
- Lacustrine (on enclosed bay)	% of area x 6
- Lacustrine (exposed to lake)	% of area x 4

(Maximum possible = 10)

In evaluating wetland complexes for site, the same considerations apply as in 1.1.3. above.

1.1.5. Nutrient Status of Surface Water

Water that is more charged with dissolved solids and nutrients can produce more biomass than water with fewer nutrients.

Water quality provides an indication of the habitat suitability of a wetland for certain plants, aquatic invertebrates, fish and wildlife. Measurement of total dissolved solids (T.D.S.) by means of specific conductance can be used to detect man-induced changes in wetlands. Conductivity measurements are interpreted as a measure of the fertility of the water and have become a standard, reliable method of measurement.

Other means of measuring the nutrient status of water in a wetland have been extensively utilized, such as pH; total alkalinity; dissolved oxygen; transparency and turbidity, along with T.D.S. and specific conductance, as well as direct measures of phosphates, nitrates, etc. However these measurements would be too time consuming for use in this evaluation.

Evaluation:

Total Dissolved Solids (T.D.S.) after temperature conversion (mg./l).

<100 mg/l	= 0
100 to 500 mg/l	= 20
501 to 1,500 mg/l	= 10
>1,500 mg/l	= 0

(Maximum possible for Nutrient Status of Surficial Water = 20)

(Maximum possible for 1.1, PRODUCTIVITY VALUES = 80)

1.2. DIVERSITY VALUES

Wetlands which contain many kinds of aquatic and terrestrial habitat together with a relatively large number of wetland plant species will invariably also attract far more animal species than wetlands containing more uniform environments and monocultures of plants (Greeson et. al. 1978). Wetlands with greater diversity meet the living requirements of more species. They provide alternate food sources for host and prey, parasites and predators and more readily permit either the temporary or permanent survival of many species. In short, whatever are the causes or the benefits of diversity it is considered to be of paramount value because more wildlife species, often in great abundance, can be found in diverse environments.

Diversity values of a wetland are evaluated under six different categories: number of wetland types, vegetation communities, diversity of surrounding habitat, proximity to other wetlands, interspersion and open water types.

1.2.1. Number of Wetland Types

The more wetland types that are present within a single wetland, the more diverse the habitat available for wildlife. Hence, the greater the diversity of wildlife species in the wetland as a whole. Golet (1976) considered a number of wetland types to be a very important contributor to total diversity. A wetland containing more than one wetland type should not be confused with a wetland complex; the latter may or may not be comprised of different wetland types but the individual wetlands are always separated by non-wetland environments.

Evaluation:

Number of Types

One = 3
Two = 6
Three = 9
Four or Five = 12

(Maximum possible = 12)

1.2.2. Vegetation Communities

Vegetation communities are the most important measure of diversity. This is because more than any other factor, plants can satisfy every major requirement of wildlife except water. Vegetation provides nesting materials and sites, protection from predators, food, places to roost, loaf, isolation during the breeding season, etc. The more kinds of vegetation communities present, and the greater the number of vegetation strata, the more valuable is the wetland. Many studies have shown that for the large majority of species, differences in vegetation are more important to quality wildlife habitat than differences in individual plant species making up the plant communities. Most wildlife species are adapted primarily to one or a complex of life forms and, as a result, wildlife diversity in any area is closely related to life form diversity which in this evaluation is measured through vegetation communities.

Evaluation:

Give two points for each single strata subform, three for each double strata community and four for each triple strata community present in the wetland.

In wetland complexes, each wetland in the complex should be mapped for its vegetation communities. In other words all the wetlands in the complex should be treated as one for purposes of evaluating vegetation communities.

(Maximum allowable = 30)

1.2.3. Diversity of Surrounding Habitat

Wetlands cannot be evaluated in isolation from surrounding habitat since not only do many wetland species need certain kinds of upland habitat during some periods in their life cycle but many upland species make use of the wetland either daily or at certain times of the year. In general, the greater the diversity of habitat immediately surrounding the wetland the greater will be the wildlife value of the wetland. Highly diverse upland habitat may include a mixture of agricultural fields, both pastured and cultivated, fence rows or shelterbelts with protective cover, forests, abandoned farmland, lakes, creeks or ponds, and an undulating terrain. Intense human activity adjacent to a wetland may deter many species from ever utilizing the wetland. Surrounding natural habitat may serve as a "buffer", reducing disturbance of wildlife and satisfying some of their requirements. Many animals may use wetlands for a specific period in their life cycle and unless the wetland is easily accessible to them, it serves them little purpose.

Evaluation:

- Ten or more kinds of surrounding habitat including forested land	10
- Six to nine kinds of surrounding habitat including forested land	7

- Two to five kinds of surrounding habitat including forested land 4

- Surrounding habitat made up of row crop agriculture 1

In the case of individual wetlands this variable pertains to all uplands within 1.5 km of the wetland; in wetland complexes, surrounding habitat pertains to uplands between and among the different wetlands of the complex as well as lands up to 1.5 km from the edge of any wetland of the complex.

(Maximum possible = 10)

1.2.4. Proximity to Other Wetlands

Where wetlands are located so near to each other that wildlife can move from one to another to take advantage from time to time of more favourable habitat, food suppply, etc. then the value of a wetland is enhanced (Golet 1976). Wetlands connected hydrologically by surface water are the most valuable. Obviously, wetlands within a defined wetland complex are all proximal to each other.

Evaluation:

In the case of individual wetlands this variable pertains to all wetlands within 1.5 km; in the case of wetland complexes proximity pertains to wetlands within the complex.

(a) Wetland Complexes 10

(b) Single Wetlands

- hydrologically connected by surface water to other wetlands (diff. dominant type) or open water within 1.5 km.

OR

- hydrologically connected by surface water to other wetlands (same dominant type) within .5 km. 10

- hydrologically connected by surface water to other wetlands (diff. dominant type) or open water body from 1.5 to 4 km away;

OR

- hydrologically connected by surface water to other wetlands (same dominant type) from .5 to 1.5 km away;

OR

- Within .75 km of other wetlands (diff. dominant type) or open water body, but not hydrologically connected by surface water. 6
- Within 1 km of other wetlands, but not hydrologically connected by surface water. 2
- No wetland within 1.5 km. 0

(Maximum possible = 10)

1.2.5. Interspersion

Interspersion is an expression of the amount of "edge" available to wildlife. Edge is defined as the rather abrupt transition zone or ecotone between any two vegetation forms or subforms as for example, the area where floating vegetation contacts emergents, emergents contact shrubs or trees, etc. Most wildlife species depend upon more than one habitat type and often prefer the "edge" areas between different habitat types. Often, the number of species and the population density of some of the species are greater in the ecotone than in the communities flanking it (Odum, 1971). As the interspersion of wetland vegetation increases, diversity of habitat is enhanced.

Evaluation:

Type 1 = 6
Type 2 = 12
Type 3 = 20
Type 4 = 28

In evaluating wetland complexes for interspersion one should examine the degree of interspersion in each wetland in the complex, then draw a conclusion as to which interspersion type might best describe the complex as a whole. A subjective decision is required.

(Maximum possible = 28)

1.2.6. Open Water Types

This index describes another facet of the edge effect - the relative proportion and areal configuration of open water to vegetated areas. This may be critical to the survival of certain wildlife species, especially waterfowl that thrive best when there is dense cover for nesting and open water for feeding, a cover-to-water ratio approaching 1:1 is optimal (Golet, 1976).

Evaluation:

No open Water = 0
Type 1 = 8
Type 2 = 8
Type 3 = 14
Type 4 = 20
Type 5 = 30
Type 6 = 8
Type 7 = 14
Type 8 = 3

(Maximum possible = 30)

(Maximum possible for 1.2, DIVERSITY VALUES = 120)

1.3. SIZE (Biological Component)

Wetlands are often valued for their size, since the larger a wetland the more likely it will contain various valuable features or expressions. In this evaluation the value given to a particular wetland for its size is always closely tied to quality of the wetland and the best measure of wetland quality is considered to be diversity. In contrast, the use of primary productivity variables appear to be irrelevant or misleading. Thus a large "poor quality" wetland made up of only cattail mats is considered to be considerably less valuable than another of the same size which contains abundant open water, is highly interspersed and provides a stopover place for migrating waterfowl, for example. The value of size is therefore closely correlated with diversity, all of whose component values are "size dependent". Thus, diversity when coupled with size appears to provide an excellent indicator of the "biological" value of a wetland. In the evaluation, a special table has been prepared aimed at quantifying the value of size as a function of diversity. The relation between size and the size-dependent diversity score is not linear; adjustments have been made in the table to ensure that large but low diversity wetlands do not receive high scores for size and also to ensure that small, highly diverse wetlands receive extra size points. Making size a function of diversity would appear to optimize the accuracy of the size values.

SIZE (BIOLOGIAL COMPONENT) EVALUATION TABLE

No. of Hectares*	Total Diversity Score 11-20	21-30	31-40	41-50	51-60	61-70	71-80	81-90	91-120
<2	4	17	10	16	26	35	42	48	50
2 - 4	5	8	12	17	28	38	44	49	50
4 - 8	5	9	13	21	30	40	46	50	50
8 - 12	6	10	15	22	32	42	48	50	50
12 - 17	6	11	16	23	34	44	50	50	50
17 - 23	6	12	18	24	36	46	50	50	50
23 - 28	7	13	19	26	38	48	50	50	50
28 - 37	7	14	21	27	41	49	50	50	50
37 - 49	7	14	22	29	43	50	50	50	50
49 - 62	8	15	23	31	45	50	50	50	50
62 - 81	8	16	24	33	46	50	50	50	50
81 - 105	9	17	25	35	47	50	50	50	50
105 - 137	9	18	26	37	48	50	50	50	50
137 - 178	10	18	27	39	49	50	50	50	50
178 - 233	10	19	28	41	50	50	50	50	50
233 - 302	11	19	29	43	50	50	50	50	50
302 - 393	11	20	30	45	50	50	50	50	50
393 - 511	11	20	31	46	50	50	50	50	50
511 - 665	12	21	32	47	50	50	50	50	50
665 - 863	12	21	33	48	50	50	50	50	50
863 - 1,123	13	22	35	48	50	50	50	50	50
1,123 - 1,460	13	22	36	49	50	50	50	50	50
1,460 - 1,898	14	23	37	49	50	50	50	50	50
1,898 - 2,467	14	24	39	50	50	50	50	50	50
>2,467	15	25	40	50	50	50	50	50	50

(Maximum possible for 1.3, SIZE (Biological Component) = 50)

* Intervals for size were arrived at in the following manner: the first size category is less than 2 hectares, the second adds 2, the third adds 3, and the 4th adds 4 (i.e. 8 to 12). Thereafter, all intervals are a product of the previous maximum number x a factor of 1.3. This permitted 25 size groupings to be created. Wetlands larger than 2,467 hectares are deemed to be identical for comparative purposes.

(Maximum possible for 1.0, BIOLOGICAL COMPONENT = 250)

APPENDIX M

Ontario Government Checklist

AN EVALUATION SYSTEM
FOR
WETLANDS OF ONTARIO
SOUTH OF THE PRECAMBRIAN SHIELD

FIRST EDITION

PART III. WETLAND DATA RECORD

WILDLIFE BRANCH
OUTDOOR RECREATION GROUP
ONTARIO MINISTRY OF NATURAL RESOURCES
AND
CANADIAN WILDLIFE SERVICE, ONTARIO REGION
ENVIRONMENTAL CONSERVATION SERVICE
ENVIRONMENT CANADA

MARCH 1983

Disponible également en français

WETLAND DATA RECORD

(i). WETLAND NAME AND/OR NUMBER ____________________

(ii). ADMINISTRATIVE REGION ____________, AND DISTRICT ____________
OF ONTARIO MINISTRY OF NATURAL RESOURCES

(iii). CONSERVATION AUTHORITY JURISDICTION ____________________

If not within a designated Conservation Authority, check here ___

(iv). COUNTY AND REGIONAL MUNICIPALITY ____________________

(v). TOWNSHIP ____________________

(vi). LOTS AND CONCESSIONS ____________________

____

(vii). MAP AND AIR PHOTO REFERENCES

(a) Longitude and Latitude ____________________

(b) U.T.M. Grid Reference Zone: _______; Grid: ____________

(c) National Topographic Series Scale and Map Number(s) & Name ______

____

(d) Air Photos

(1) Date photo taken ____________________

(2) Scale of air photos ____________________

(3) Flight and plate numbers ____________________

____

(viii). WETLAND SIZE AND BOUNDARIES

(a) Single contiguous wetland area: ____________ hectares

OR

(b) "Wetland Complex" comprised of ______ individual wetlands as follows:.

Wetland Number (for reference purposes)	Size of each wetland in the complex	
Wetland No. 1	________	hectares
Wetland No. 2	________	"
Wetland No. 3	________	"
Wetland No. 4	________	"
Wetland No. 5	________	"
Wetland No. 6	________	"
Total size of wetland complex:	________	"

1.0. BIOLOGICAL COMPONENT

1.1. PRODUCTIVITY VALUES

1.1.1. Growing Degree-Days

Number of accumulated growing degree days (check one)

_____ <2800
_____ 2800 - 3200
_____ 3200 - 3600
_____ >3600

1.1.2. Soils

	Estimated % of Area
- Loams, clays or silts (mineral)	_____
- Organic	_____
- Undesignated	_____

1.1.3. Type of Wetland

(check one or more)		Estimated % of Area
_____	Bog	_____
_____	Fen	_____
_____	Carr	_____
_____	Swamp	_____
_____	Marsh	_____

1.1.4. Site

(check one or more)		Estimated % of Area
_____	Isolated	_____
_____	Palustrine with intermittent outflow	_____
_____	Palustrine with permanent outflow	_____
_____	Riverine (near headwaters)	_____
_____	Riverine (mid-river)	_____
_____	Riverine (near mouth)	_____
_____	Lacustrine (at rivermouth)	_____
_____	Lacustrine (on enclosed bay)	_____
_____	Lacustrine (exposed to lake)	_____

1.1.5. Nutrient Status of Surface Water

Write conductivity bridge reading and calculate T.D.S. at 25o as per tables in Appendix VI of 1.1.5. in the Procedures Manual.

Initial Specific conductance Micromhos/cm (umhos/cm)		Total Dissolved Solids T.D.S. Temperature Conversion (mg/l)
______________________	=	______________________

1.2. DIVERSITY VALUES

1.2.1. Number of Wetland Types

_____ one
_____ two
_____ three
_____ four
_____ five

1.2.2. Vegetation Communities

(a) Single Stratum Subforms (check)	Dominant Species
_____ Deciduous Trees	____________________
_____ Coniferous Trees	____________________
_____ Dead Trees	____________________
_____ Tall Shrubs	____________________
_____ Low Shrubs	____________________
_____ Herbs	____________________
_____ Mosses	____________________
_____ Robust Emergents	____________________
_____ Narrow-leaved Emergents	____________________
_____ Broad-leaved Emergents	____________________
_____ Floating Plants	____________________
_____ Free-floating Plants	____________________
_____ Submergents	____________________

(b) Double Strata Subforms (list)

Upper Stratum	Lower Stratum
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________
____________________	____________________

(c) Triple Strata Subforms (list)

Upper Stratum	Middle Stratum	Lower Stratum
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________
____________	____________	____________

1.2.3. Diversity of Surrounding Habitat
(check all appropriate items)

_____ row crops
_____ pasture
_____ abandoned agricultural land
_____ deciduous forest
_____ coniferous forest
_____ urban or cottage development
_____ pits, quarries or mining waste disposal
_____ open lake or deep river
_____ fence rows with cover, or shelterbelts
_____ terraine undulating or hilly with ravines
_____ creek(s)

1.2.4. Proximity to Other Wetlands
(check one or more)

___ hydrologically connected by surface water to other wetlands (diff. dominant type) or open water within 1.5 km.

OR

___ hydrologically connected by surface water to other wetlands (same dominant type) within .5 km.

___ hydrologically connected by surface water to other wetlands (diff. dominant type) or open water body from 1.5 to 4 km away;

OR

___ hydrologically connected by surface water to other wetlands (same dominant type) from .5 to 1.5 km away;

OR

___ Within .75 km of other wetlands (diff. dominant type) or open water body, but not hydrologically connected by surface water;

___ Within 1 km of other wetlands, but not hydrologically connected by surface water.

___ no wetland within 1.5 km.

1.2.5. Interspersion

(check one)

_____ Type 1
_____ Type 2
_____ Type 3
_____ Type 4

1.2.6. Wetland Open Water Types

(check one)
Enter type as per map in Figure 10

_____ No open water
_____ Type 1
_____ Type 2
_____ Type 3
_____ Type 4
_____ Type 5
_____ Type 6
_____ Type 7
_____ Type 8

1.3. SIZE (Biological Component)

(refer to viii)

_______________ hectares

2.0. SOCIAL COMPONENT

2.1. RESOURCE PRODUCTS WITH CASH VALUE

2.1.1. Timber

_____ 51 to 100% of the wetland is a swamp with many mature trees (over 10 m. tall).
_____ 10 to 50% of the wetland is a swamp as above
_____ wetland has few, small or no trees

Source of information: ______________________________

2.1.2. Wild Rice

_____ wild rice present in the wetland
_____ wild rice not present

Source of Information: ______________________________

2.1.3. Commercial Fish (Bait Fish and/or Coarse Fish)

_____ fish harvested from the wetland (as per MNR)
_____ abundant during at least part of the year
_____ not abundant or only occasional
_____ habitat not suitable for fish

Source of Information: ______________________________

2.1.4. Bullfrogs

______ Present
______ Absent
Source of Information: ______________________

2.1.5. Snapping Turtles

______ Present
______ Absent
Source of Information: ______________________

2.1.6. Fur Bearers (check if present)

______ muskrat
______ raccoon
______ beaver
______ mink
______ other
Source of Information: ______________________

2.2. RECREATIONAL ACTIVITIES (check appropriate column)

	Type of Wetland Associated Use			
Intensity of Use	Hunting	Nature Appreciation or Study	Fishing	Canoeing/Boating
High				
Moderate				
Low				
None Known				
Not Possible				

2.3. AESTHETICS

2.3.1. Landscape Distinctness

______ clearly distinct
______ indistinct

2.3.2. Absence of Human Disturbances

2.3.2.1. Level of Disturbance

______ human disturbances absent or nearly so;
______ one or several singular or localized disturbances;
______ moderate disturbance or localized water pollution;
______ impairment of natural quality intense in some areas or severe localized water pollution;
______ extremely intense disturbance or water pollution severe and widespread.

2.3.2.2. Types of Disturbances

______ roads
______ utility corridor
______ buildings
______ channelization
______ drainage
______ filling
______ water pollution
______ other: ______________________________.

2.4. EDUCATION AND PUBLIC AWARENESS

2.4.1. Educational Uses

______ Frequent - an average of 2 or more visits per year by one or more school groups, local clubs for the purpose of studying the animals, plants, environment, etc.
______ Infrequent - use by organized groups (one visit or less per year or only casual visits)
______ No known visits

List groups utilizing the wetland

	Name of Group	Source of Information
(a)	______________________	______________________
(b)	______________________	______________________
(c)	______________________	______________________

2.4.2. Facilities and Programs (check one)

______ staffed interpretation center with shelters, trails, literature
______ no interpretation center or staff, but a system of self-guiding trails and observation points; brochures may be available
______ no facilities or programs

2.4.3. Research and Studies (check one)

______ one or more wetland-related scientific research papers published in a scientific journal;
______ one or more reports written outlining some aspect of the wetland's natural resources;
______ no reports or papers.

List scientific papers, reports, ec.

(a) ______________________________
(b) ______________________________
(c) ______________________________
____

2.5. PROXIMITY TO URBAN AREAS (check one)

______ in an urban or suburban area
______ <10 km from a population center greater than 10,000
______ 10 to 60 km from a population center greater than 10,000
______ isolated or relatively remote

2.6. OWNERSHIP/ACCESSIBILITY

2.6.1. Ownership

% of Area (estimate)

______ public land with unrestricted access
______ public land with restricted access
______ private, but open to the public for limited activities
______ private club, closed to public
______ private and restricted

2.6.2. Accessibility (check one)

______ easily accessible at most times by road or waterway
______ easily accessible only at certain times of the year
______ limited accessibility and moderate effort required
______ access difficult

2.7. Size (Social Component)

______ hectares (refer to viii)

3.0 HYDROLOGICAL COMPONENT

3.1. FLOW STABILIZATION

3.1.1. Detention Due to Surface Area

3.1.1.1. Size of catchment basin above wetland outflow in relation to total size of all wetlands, reservoirs and lakes above the wetland.

Catchment Basin Size __________ sq. km.

3.1.1.2. Total Size of all Detention Areas (Lakes, Reservoirs and Wetlands) Draining into the Wetland (in sq. km.)

List Detention Areas	Size
______________________________	______
______________________________	______
______________________________	______
______________________________	______
______________________________	______
______________________________	______
______________________________	______
Total	______ sq. km.

3.1.1.3. Size of Adjoining Lake (Lacustrine wetlands only)

______ hectares or _______ sq. km.

3.1.1.4. Size of Adjoining River (Riverine Wetlands only) (check one)

______ Wetland located on the Ottawa, St. Lawrence, Niagara, Detroit or St. Clair Rivers.
______ Wetland not on any of the above rivers.

3.1.1.5. Location and size of detention areas (lakes, reservoirs and wetlands) within 30 km above and below the wetland.

(a) Detention areas above the wetland (Within 30 km.)

Name and/or Number of Detention Area	Distance upstream from wetland (in km.)	Size	Cumulative Size

(b) Detention areas below the wetland (Within 30 km.)

Name and/or Number of Detention Area	Distance downstream from wetland (in km.)	Size	Cumulative Size

3.1.1.6. Land use along river or stream shoreline for 20 km below the wetland (for Palustrine and all Riverine Wetlands except those located along the 5 large rivers).

_______ km. village, town or urban
_______ " actively farmed agricultural
_______ " forested
_______ " abandoned by agriculture
_______ " other (state) _______________.
40 " = Total in km. (i.e. 20 km on each side of the river or stream)

3.1.1.7. Size (Hydrological Component) (see viii) __________ hectares

3.1.2. Flow Augmentation

Wetland Catchment basin __________ sq. km. (See 3.1.1.1.)
Wetland Area as a % of Catchment Basin Size _____%

3.2. WATER QUALITY IMPROVEMENT

3.2.1. Short Term Removal of Nutrients from Surface Water

3.2.1.1. Site Type (see 1.1.4. and check one)

_______ Isolated
_______ Palustrine with intermittent outflow
_______ Palustrine with permanent outflow
_______ Riverine (near headwaters)
_______ Riverine (mid-river)
_______ Riverine (near mouth)
_______ Lacustrine (at rivermouth)
_______ Lacustrine (on enclosed bay)
_______ Lacustrine (exposed to lake)

3.2.1.2. Actual Wetland Area with Robust Emergents and Submergents (check one)

_______ 0 or <5
_______ 5 - 50
_______ 51 - 100
_______ 101 - 250
_______ 251 - 500
_______ 501 - 1000
_______ >1000 hectares

3.2.1.3. Land Use in Catchment Basin (check one)

_______ mainly agriculture and/or urban
_______ roughly 40-60% agriculture; remainder forested or or abandoned agriculture
_______ mainly forested

3.2.2. Long Term Nutrient Trap (check one)

_______ wetland located on an active delta
_______ wetland lacustrine - rivermouth but without obvious delta
_______ wetland with organic soils occupying 50% or more of the area
_______ wetland with organic soils occupying less than 50% of the area

3.3. EROSION CONTROL

3.3.1. Erosion Buffer

3.3.1.1. Riverine Wetlands (check principal vegetation form)

_______ Trees or Shrubs
_______ Emergents
_______ Submergents and Floating
_______ Non-vegetated or nearly so

3.3.1.2. Lacustrine Wetlands (check principal vegetation form)

_______ Forest or Shrubs
_______ Emergents
_______ Submergents and Floating
_______ Non-vegetated or nearly so

3.3.1.3. Fetch (Lacustine Wetlands and/or Riverine wetlands on any of the 5 large rivers)

Maximum distance
_______ <2 km
_______ 2-8 km
_______ >8 km
_______ barrier beach present

3.3.2 Sheet Erosion

For all except Lacustrine wetlands
(check the appropriate square)

R Factor Value

Wetland Size sq. km.	<50	51-75	76-100	>100
<1				
1-5				
6-10				
11-15				
16-20				
>20				

4.0. SPECIAL FEATURES COMPONENT

4.1 RARITY AND/OR SCARCITY

4.1.1. Individual Wetlands

Name of physiographic unit: ____________
Number of unit: ______

4.1.2. Wetland Type Representation (check one or more)

marsh ______
swamp and/or carr ______
fen ______
bog ______

4.1.3. Individual Species

4.1.3.1. Breeding habitat for an endangered animal or plant species:

	Name of Species	Source of Information
(1)		
(2)		

4.1.3.2. Traditional migration or feeding habitat for an endangered animal species:

	Name of Species	Source of Information
(1)		
(2)		

4.1.3.3. Breeding or feeding habitat for a provincially significant animal species:

	Name of Species	Source of Information
(1)		
(2)		

4.1.3.4. Provincially significant plant species:

	Name of Species	Source of Information
(1)		
(2)		

4.1.3.5. Regionally significant species:

	Name of Species	Source of Information
(1)	________	________
(2)	________	________
(3)	________	________
(4)	________	________

4.2. SIGNIFICANT FEATURES AND/OR FISH AND WILDLIFE HABITAT

4.2.1. Nesting of Colonial Waterbirds (check one)

________ currently nesting; species name(s) ________
________ known to have nested within past 5 years;
species name(s) ________ ________
________ active feeding area
________ none known
Source of Information: ________

4.2.2. Winter Cover for Wildlife (check only highest level of significance)

________ Provincially signficant for Deer ____, Moose ____
________ Regionally significant for Deer ____, Moose ____
________ Locally significant for Deer ____, Moose ____
________ Good winter cover for other species (list): ________
____
____
________ Poor winter cover
Source of Information: ________

4.2.3. Waterfowl Staging (check only highest level of significance)

________ Canadian significance
________ Provincial significance
________ Regional signficance
________ Little or no significance
Source of Information: ________

4.2.4. Waterfowl Production (check only highest level of significance)

________ Provincial significance
________ Regional significance
________ Local significance
Source of Information: ________

4.2.5. Migratory Passerine Stopover Area (check one)

________ Highly significant
________ not singularly significant
Source of Information: ________

4.2.6. Significance for Fish Spawning and Rearing (check one)

__________ Regional Significance
__________ Present
__________ Unknown
__________ Not possible
Species and Source of Information: ________________
____

4.2.7. Unusual Geological or other Surficial Features

Feature	Source of Information
(1) ______________________	______________________
(2) ______________________	______________________

4.3. ECOLOGICAL AGE

Type of Wetland	% Area
________ Bog	______
________ Fen	______
________ Swamp/Carr	______
________ Marsh	______

INVESTIGATORS

(a) ____
(b) ____
(c) ____

AFFILIATION

____

DATE

____

ESTIMATED TIME DEVOTED TO COMPLETING THE FIELD SURVEY IN "PERSON HOURS"

______________________.

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